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THESIS

U.S. PORT DEVELOPMENT AND THE EXPANDING WORLD COAL TRADE: A STUDY OF ALTERNATIVES

by

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June 1982

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I. INTRODUCTION AND OBJECTIVES

A. GENERAL

The second major increase in world oil prices after the shock of the initial embargo of 1973, occurred in 1979. This new price hike effected a conversion of many of the remaining doubters or "fence-sitters" worldwide to a belief in the need for strenuous efforts to develop alternative, less costly forms of energy. The most readily available source of industrial fuel was coal, which the United States has in abundance. Reaction in the world energy market caused the overall demand for U.S. coal to soar 39 percent from 1979 levels to 90 million tons in 1980 [Ref. 1: p.4]. As a consequence of this rise, even skeptical observers now maintain that after a period of market normalization, world-wide need for U.S. coal will continue to expand at a rapid rate and, by the year 2000, will have grown to a trade of more than a quarter of a billion tons per year [Refs. 1: p.5; 2: p.492]. As the world's greatest source of recoverable coal reserves, the U.S. is bound to play a significant part in future world coal trade. Whether this part will be passive or active and the extent of its eventual market share depend in large measure on policy decisions which must be made by the federal government in the near future.

Export coal consists of two types: metallurgical (coking) coal, used in the manufacture of steel and other alloys, and steam coal which is burned in the generation of electrical power. The market for both commodities worldwide is virtually assured, although the increase in coal demand during the last three years has been based largely on a

disproportionate increase in the steam coal market. According to Ulf Lantzke, the Director of the highly respected, Paris-based, International Energy Agency, "the world coal supply must at least triple by the end of this century if we are to have adequate energy supplies to accommodate even moderate levels of growth" [Ref. 3: p.351]. This projection appears to be based solely on routine economic growth and does not consider the reliability of petroleum sources in the politically unstable Persian Gulf states over the next 20 years, nor the continued public uneasiness and the political hazards associated with continued efforts to expand the use of nuclear power in public utilities.

According to several authoritative sources [Refs. 1;2;3], the expanded use of coal not only eases worldwide economic development in a general sense, but has two specific benefits for the U.S. First, as a major supplier of coal the U.S. may bind its allies closer and gain more support in foreign policy since these nations in substituting coal for other energy forms will emancipate themselves from the threat of a third world oil embargo. Second, the balance of payments implications of projected coal export increases are enormous. Revenues of $30 billion dollars per year from coal exports alone may be possible by the year 2000. These benefits are not, however, inevitable. They are dependent on specific governmental action.

The U.S. has failed to formulate a distinct public policy on coal export, other than noncommitally, through generally supportive statements as to the importance of increased coal usage in the developed nations. Economic summits, such as that held in Venice in 1979, have served as forums for the issuance of these calls for international cooperation between the developed nations to boost the

international coal trade. Specific governmental actions, however, are not in evidence. Definitive policy is needed, particularly in the port loading and ocean transportation links of the mine to market economic chain of export coal (see Figure 1.1). The importance of these two links is associated with the cost structure peculiar to U.S. export coal. The cost components of loading and shipping coal are most amenable to change due to capital and labor concentrations related to the various links in the coal chain through which pricing is derived. A direct consequence of pricing is the relative competitiveness which U.S. coal can achieve in the world market. This, in turn, will establish the path which the U.S. export industry will take in the future [Ref. 2: p.435].

Importers worldwide look for reasonable pricing in energy stocks and reliability in energy sources. Both of these attributes can be directly influenced by legislation and/or executive action. A clearly articulated choice on coal export and port development alternatives will provide a basic parameter to the U.S. coal export trade. Public policy, which must be made in the near term, will directly affect the U.S. position and role in the world coal market into the next century.

B. OBJECTIVE

Several competing methods of marine coal loading have been advocated, yet no prioritization of these developmental proposals exists [Ref. 1: p.9]. The objective of this study is to provide a method for the systematic formulation of fundamental public policy regarding the future development of marine loading terminals to meet and stimulate the demand for U.S. export coal. This policy will be stated in such a way that a clear choice and prioritization of the several candidate courses of action can be made.

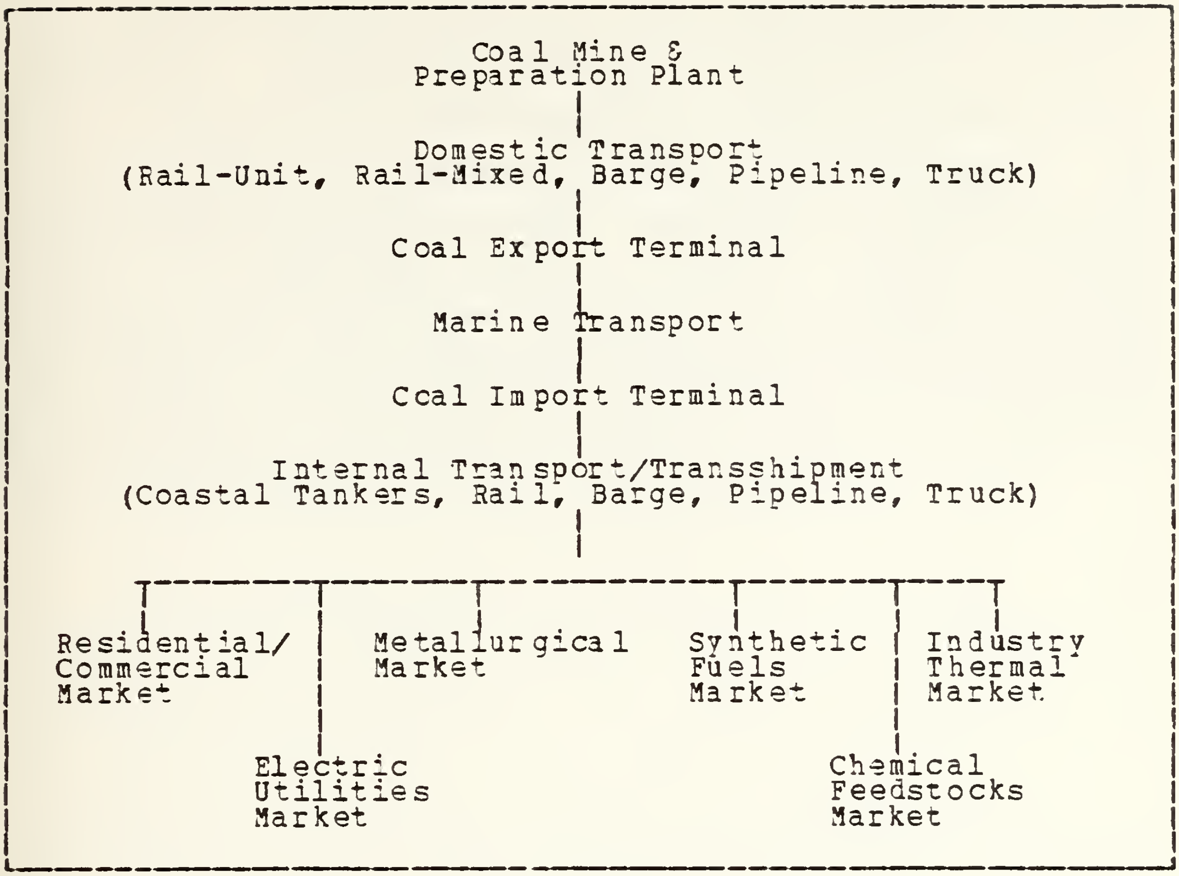


Figure 1.1 Typical Export Coal Chain

Chapter II provides a detailed background of the current and projected state of the world export coal industry and the role which the U.S. could play. Chapter III contains a discussion of marine development issues, a description of alternative forms of marine loading terminals, and a cost-benefit analysis to determine the best policy for the federal government to adopt to stimulate this segment of foreign trade. The specific purpose here is to determine the method most likely to meet the requirements of increased capacity and competitive low cost for U.S. export coal through the year 2000 under conditions of low to medium risk. This, in essence, is a risk averse prioritization of

the candidate projects with the development costs considered secondarily. Chapter IV provides a second level of refinement of the evaluation and includes a method for the prioritization of coal port dredging projects in the U.S. This ranking method provides a clear statement of which projects should be undertaken first to gain maximum capacity increases for a given cost ceiling. This analysis concludes with Chapter V wherein general conclusions from the research are integrated with policy recommendations and suggestions for further research in this field are made.

II. COAL EXPORT ISSUES

This chapter presents the background of the coal export trade issues currently facing both government and commerce. It provides the foundation upon which subsequent analysis is built. The first section of the chapter briefly summarizes the history of coal export from the Unites States up to 1979. The second section discusses the radical changes which have occurred in the world coal market since 1979, which have given rise to forecasts of a greatly increased U.S. role in the export market. The third and fourth sections present the competing, though sometimes complementary, proposals for coal terminal systems development which the U.S. government may choose to support, together with a description of the government's historical role in the general development of marine terminals in support of U.S. trade.

A. BACKGROUND OF THE U.S. COAL EXPORT INDUSTRY

As the early settlers advanced inland from the Eastern seaboard, the initial coal deposits which would provide the fuel and raw material for the Industrial Revolution in the United States were discovered in the Appalachian Mountains of Pennsylvania, Virginia and West Virginia. By the late nineteenth century a small export trade in metallurgical coal had developed with Canada and the east coast of South America. This trade gradually increased to 38 million tons per year in 1920 before dropping off to 9 million tons in 1932 during the depths of the Great Depression [Ref. 1: p.34]. Peaks were again reached in 1947 (69 million tons) and 1957 (76.4 million tons), the all time

pre-1980 high [Ref. 4: p.59]. While coal has been found in 31 of the 50 states, the infrastucture which developed for the export of coal to countries other than Canada has developed principally around four East Coast marine terminals operated by regional railroads at Hampton Roads, Baltimore, and to a much smaller extent Philadelphia and Mobile. Coal is also found in great abundance in the Rocky Mountain and Great Plains states. The transportation network supporting mining operations in these areas goes east to the Mississippi River or west to port cities located in California, Oregon or Washington. The amount of export trade in coal from the western U.S. is still very small in comparison with its East Coast counterpart. The coal traffic conducted via the Great Lakes with Canada has been treated by the coal trade itself as a separate industry and will not be considered in this study. The two reasons for this are that the export trade in coal with Canada is expected to wane over the next 20 years and the 25,000 deadweight ton (dwt) limitation on vessels transiting the St. Lawrence Seaway effectively inhibits any real expansion of the export trade outside the confines of the Great Lakes.

The coal export trade from the United States in 1977 was one which could have been characterized as a mature industry (see Table I). This bituminous coal was used in the coking process for metallurgical and other industrial applications rather than in generation of power for utilities. Growth was moderate and projected to remain so [Ref. 4: p.61]. Apparently unaffected by the initial Arab oil embargo of 1973, petro-energy still remained relatively cheap worldwide so that finding an alternative to the then widely used oil and natural gas stocks for the generation of power had not become a critical economic factor. For all practical purposes, a meaningful export trade in steam coal to fuel

TABLE I

Bituminous Coal Exports, 1945-1977

Exports (million tons)

Year	Total	To Canada	To Japan	To Europe	Other	Percent of Domestic Production
1945	28.0	21.6	-	3.9	2.5	4.8
1950	25.5	23.0	0.2	0.8	1.5	4.9
1955	51.3	17.2	2.8	28.7	2.6	11.0
1960	36.5	11.6	5.6	16.9	2.4	8.8
1965	50.2	15.7	7.5	25.0	2.0	9.8
1966	49.3	15.8	7.8	23.0	2.7	9.2
1967	49.5	15.3	12.2	19.4	2.7	9.0
1968	50.6	16.7	15.8	15.4	2.7	9.3
1969	56.2	16.8	21.4	15.1	2.9	10.0
1970	70.9	18.7	27.6	21.5	3.1	11.8
1971	56.6	17.6	19.7	16.4	2.9	10.3
1972	56.0	18.2	18.0	16.7	3.1	9.4
1973	52.9	16.2	19.2	14.3	3.2	8.9
1974	59.9	13.7	27.3	15.9	3.0	9.9
1975	65.7	16.7	25.4	19.2	4.4	10.1
1976	59.4	16.5	18.8	19.8	4.3	8.8
1977	53.7	17.2	15.9	14.9	5.7	8.0

utilities did not exist. Excess export capacity existed, both in terms of inland transportation and marine terminal loading capabilities. No real growth in steam coal exports was forecasted by the Energy Information Administration in its report to Congress for 1977 [Ref. 4: p.61].

The power of the Organization of Petroleum Exporting Countries (OPEC) and the price of petroleum based fuels had been on the rise since the early 1970's. The fossil fuel equation, the balance of coal, petroleum and natural gas

needed to meet a nation's mass energy requirements (e.g. electric power generation), was drastically altered in 1979 when OPEC nearly doubled its product prices. The nations of Western Europe and Japan immediately sought alternative fossil fuel energy sources. Among the most readily available was steam coal abundant in both the eastern and western regions of the U.S. According to Dr. Rex Sherman, Director of Research for the American Association of Port Authorities, the U.S. exported 311,000 tons of steam coal in 1978. Total coal exports for that year were in the neighborhood of 55 million tons; steam coal represented less than one half of one percent of the trade. Oil price hikes coupled with labor problems in Australian coal mines caused 1979 U.S. steam coal exports to nations other than Canada to reach 2.5 million tons. By 1980 this trade had exploded to 16 million tons of steam coal out of an overall total of 90 million tons exported. 1981's totals, when finally computed, should indicate steam coal exports at between 25 and 30 million tons on total exports of 110 million tons. This represents a fifty-fold increase in the quantity of steam coal exported from the U.S. in a period of three years. While demand in this market has softened somewhat during the first quarter of 1982 as a result of stockpiling by European nations and the worldwide economic slowdown, the long term prospects for increases in the export of steam coal remain excellent.

This surge in demand, while a boon to East Coast coal operators and major coal exporting railroads such as the Norfolk & Western and the CSX system, created chaos at the ill-prepared major marine loading points. For example, through 1980 Hampton Roads had as many as 60 colliers at a time waiting in the roadstead. These ships were delayed in loading an average of six weeks, incurring daily demurrage

costs of between $15,000-20,000 per ship. [Ref. 5: p.1]. Demurrage is the cost of operating a vessel while it is waiting for a berth to take on its cargo and raises the final cost of this cargo at its destination. This waiting cost is truly a no-win situation since it can be translated directly into lower profits for both the importers, whose product prices go higher, and the exporters, who lose business when the price of their product rises and demand slackens. At the other extreme from the crowded conditions prevailing on the East coast, the West Coast had no dedicated coal export infrastructure at all.

Aggravating an already difficult situation was an initial reluctance by the U.S. coal export industry to enter into long term contracts with Western European and Japanese importers. These contracts would have added some measure of stability to what had become a volatile market. The basis for the caution exhibited by major coal companies like Norfolk & Western, A.T. Massey and Pittston toward long term contractual arrangements was uncertainty regarding the duration of the demand, the future of interstate freight rates for coal hauling by rail and the absence of federal government plans for port development (specifically a 55'(16.8 meters) minimum channel depth) to allow future use of large colliers in the neighborhood of 150,000 dwt in major Eastern and Gulf coast ports. The current channel depth in these ports averages 40 feet(12.2 meters), limiting collier size to 50,000-60,000 dwt. The combination of long queues of colliers outside the ports and the resultant high demurrage, spot pricing of coal, and lack of deepwater ports was, in fact, contrary to all of the major importers' objectives. The price of U.S. steam coal landed in the target market quickly rose above the competition. Our principal competitors, South Africa and Australia, were more than eager to

provide or at least plan for these same services. The gilt edges of the U.S. steam coal export market began to tarnish. Sample coal prices are provided in Table II. These prices are based on the use of colliers in the 25,000-60,000 dwt category.

TABLE II

Selected Current International Steam Coal and Shipping Prices (averaged, U.S. 1981 dollars/ton)

	Price FOB port	Ocean[1] Freight	Delivered Price
U.S. east coast to NW Europe.	$50	$18	$68
Poland to West Europe	54	8	62
South Africa to Europe	43	13	56
Australia to Europe	44	26	70
U.S. east coast to Japan	50	28	78
South Africa to Japan	43	22	68
Australia to Japan	44	16	60

[1]Ocean freight cost does not include additions of $6 to $10 per ton now charged as demurrage for those ships waiting to load at Baltimore and Hampton Roads.

Source: Coal Week International. Mar. 18 and 25, 1981.

Since 1980, some progress towards lowering demurrage has been made. The Staggers Act (1980) has lessened the federal government's regulation of the railways which has allowed two major coal exporters, Norfolk & Western and the CSX System to enter into longer term contracts with foreign importers. An interview with a spokesman for the Virginia Port Authority [Ref. 31], a state agency controlling the operations of the Port of Hampton Roads, indicated that these contracts coupled with increased efficiencies in rail transport and yard operations by the Norfolk & Western have been effective in reducing the queue of colliers to be loaded and the average waiting time to twenty ships and two to three weeks, respectively. Moreover, this queue is to

load coal not under contract. The delay for vessels under long term contract has been reduced to zero through a reservation system with two-way penalties. If either the exporter or the importer is not prepared to load on the agreed upon date, then the party responsible will be held liable for the additional costs incurred as a result of that delay. Industry spokesmen remain unsure of future demand stability because of the anticipated use of the super-colliers (150,000 - 200,000 dwt) in the post-1990 timeframe (see Appendix A) and are already clamoring for expedited action on port dredging operations [Ref. 6: p.30].

TABLE III

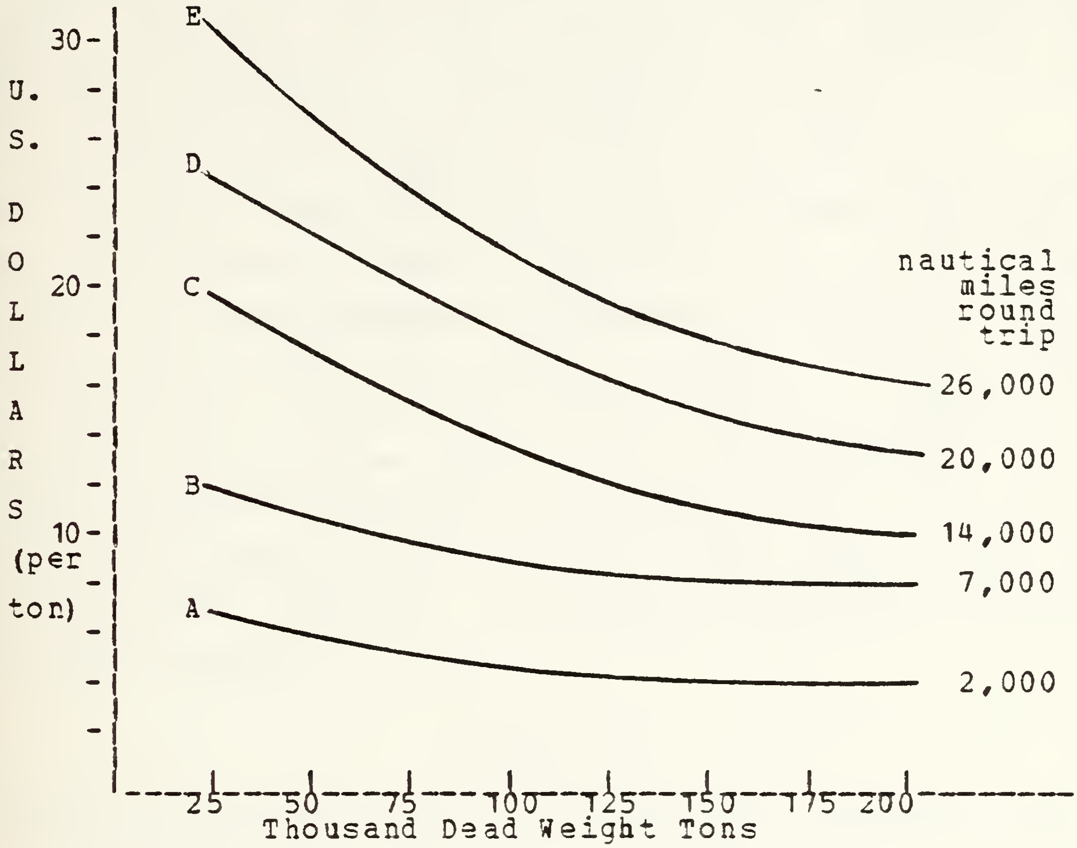
Average Daily Cost of Vessels

	60,000 dwt	100,000 dwt	150,000 dwt
Daily Capital Cost	$10,300	$13,977	$18,229
Daily Fuel Cost	17,400	21,900	24,300
Daily Vessel Expenses	3,900	4,623	5,233
Total	31,600	40,500	47,762
Daily Cost Per Ton	.527	.405	.318

Source:
Maritime Administration, December 1980 [Ref. 9: p.22].

While demurrage may be down from highs of $8 to $10 per ton of loaded coal [Ref. 7: p.13] as a result of contractual expediting and efficiencies gained ashore, this temporary advance toward the solution to the coal problem will soon be eclipsed by deficiencies in terminal capacities and the increasing burden of ocean transport costs [Refs. 1; 2; 3; 7]. The latter represents 20 to 30 percent of the overall cost of delivered coal [Ref. 8: p.173]. Table III depicts the economies of scale to be gained in

vessel operating costs through the use of larger ships. Figure 2.1 demonstrates the effect on the price of a ton of coal through the use of larger ships over longer distances.



A. The distance from China to Japan or Inter-European trade.
B. The distance from United States East Coast to West Europe.
C. The distance from South Africa to Japan or West Europe.
D. The distance from North American East Coast to Japan and American West Coast to Europe.
E. The distance from Australia to West Europe.

Source: Steam Coal Prospects to 2000, OECD 1978.

Figure 2.1 Economies of Scale in Maritime Transport

Table III and Figure 2.1 lead to the same conclusion: the price of delivered coal can be lowered through the use of larger ships. The longer the distance, the greater the saving. There is a strong incentive among exporters and importers alike to lower costs in this area. The United States, however, has been restricted from enjoying these economies of scale by the controlling depth of the ports where the coal terminals are located [Ref. 10].

The net relative effect on the delivered price of coal from the major suppliers resulting from these economies of scale in shipping is shown in Table IV. This table has been derived from the information contained in Table II, Figure 2.1 and other price data available from industry sources. Delivered price is the sum of the freight on board (FOB) cost of the coal at the loading port plus the ocean freight charges. Table IV indicates that the potential for greatest price improvement is in the East Coast coal trade with Europe in which the U.S. can become much more competitive with South Africa.

TABLE IV

Comparative Price of Coal at Destination by Vessel Size

	Delivered Price	
	60,000 dwt	150,000 dwt
To Europe from:		
United States (east coast)	$63	58
South Africa	56	54
Australia	70	61
To Japan from:		
United States (west coast)	70	63
South Africa	68	54
Australia	60	55

B. U.S. COAL EXPORT PROJECTIONS

Intense interest in the future of the rapidly accelerating steam coal trade has been generated in the marketplace. Industry analysts discarded the low export projections presented in 1978 by the President's Commission on Coal [Ref. 4] and sought out new and more reliable sources of information. Spurred on, perhaps, by the far-sighted analysts at the International Energy Agency in Paris, the Massachusetts Institute of Technology commissioned an internationally staffed World Coal Study (WOCOL) in October 1978 to forecast the supply and demand structure associated with coal through the year 2000 [Refs. 2; 8]. The preliminary results were made available in mid-1980 and appear to have had a profound effect on importers and exporters alike. Further, the WOCOL conclusions were generally corroborated by the Carter Administration's Interagency Coal Export Task Force (ICE) formed in the spring of 1980. These two study efforts represent the base from which most subsequent analyses embark.

The projections used by WOCOL and ICE give three forecasted levels of coal export. The first is the "low coal case" which represents the minimum demand for coal through the year 2000. The second level is the "high coal case" which represents the amount of coal required worldwide if all the conversion efforts, future policy decisions, and assumptions used in the studies are carried forward. The last case is the so called "sensitivity case" which extrapolates what would happen to the figures of the "high coal case" if there were a drastically reduced use of nuclear power worldwide and the price of crude oil escalated faster than forecasted as the result of a significant curtailment of supply. This study will proceed on the assumption that the "high coal case" is the most likely.

The basic conclusions of the WOCOL and ICE studies, while startling to many, achieved immediate and near unanimous acceptance. They were bolstered by the fact that 1981 steam coal exports of approximately 30 million tons matched the WOCOL "high" case projections for 1985. The following list of points represent an amalgamation of the conclusions reached by WOCOL, ICE, the Congressional Office of Technology Assessment (OTA) and other more specific studies relating to the growth and nature of the U.S. export coal trade as they effect the objective of this analysis:

1. Coal will have to supply at least one half to two thirds of all additional energy needed for the next 20 years.
2. To meet the above requirement, world coal production must increase 2.5 to 3 times by 2000.
3. The combined world coal market will increase 3 to 5 fold during this same period, while the trade in steam coal will grow by a factor of between 5-12, from 60 million tons per year to between 300-680 million tons per year.
4. Ninety percent of the world's coal reserves are contained in the U.S.S.R., U.S., Australia and China, but the only nations which will be able to economically recover the coal and engage in meaningful trade will be the U.S., Australia, and to a lesser extent South Africa and Canada.
5. Only Australia and the U.S. have the individual potential of exporting 100 million tons of steam coal per year; only the latter's potential exceeds 200 million tons. The two nations together must supply one half of the world's new energy requirements. U.S. steam coal exports by 2000 are projected at 65-280 million tons per year with the higher end of the range given more credence (200 million tons according to ICE).

6. Long term prices and contracts are essential for the maintenance of stability in the market.
7. Major expansion of railway, barge transport and marine terminal loading systems will be required.
8. Transportation costs can be the deciding factor in establishing the balance of competition among distant sources of coal particularly with the steady increase in bunker fuel prices.
9. International shipbuilding to meet the requirements of this expanded trade must exceed 50 colliers or five million dwt per year for the next 20 years and the displacement of the average collier will grow substantially from its current average of 60,000-80,000 dwt.
10. Regulatory and institutional processes for the expansion of ports in the U.S. represent the single greatest obstacle to that nation's meeting or exceeding its market share.
11. Currently the U.S. is the only major producer of coal whose export potential exceeds importer preference.
12. Ocean transportation costs represent 20-30 percent of the overall cost of coal.
13. The United States can garner a stable share of the market as long as U.S. prices for delivered coal remain within 10 percent of its competitors.
14. Security and diversity of supply sources are nearly as important factors in the attractiveness of U.S. coal on the world market as price is.
15. Early decisions on harbor dredging are important if U.S. coal export potential is to be realized. Port expansion is already underway in Canada, South Africa and Australia.

16. Demurrage free throughput of export coal based on 1995 demand projections will require an inplace loading capacity of at least 238 million tons per year.
17. Non-conventional means for the inland transport and maritime loading of coal in the form of slurry pipelines is a proven technology.
18. Bulk carriers (excluding oil/bulk combined carriers) in excess of 60,000 dwt will make up 30 percent of the world's fleet by 1990.
19. The Mississippi River Basin portion of the Inland Waterway will not accommodate greatly increased coal barge traffic without significant up-grading of the Gallipolis lock complex and the Pittsburg-Three Rivers Region.
20. While contested by local operators, transhipment of coal through the Great Lakes will play an insignificant part in the U.S. coal export trade.
21. If the U.S. can remain competitive, the steam coal export trade will provide $15.0 billion or more annually in foreign exchange by 2000.

C. ALTERNATIVE MARINE LOADING METHODS FOR U.S. COAL

In seeking the best policy by which the federal government can most effectively stimulate the U.S. coal export trade, a key determinant is the cost of the method or methods selected for coal loading at marine terminals. The situation is, to some degree, analogous to the one faced by the federal government and the oil companies in the early 1970's. Supertankers had become a reality and had definitively lowered the transportation costs for imported oil, but no ports on the East and Gulf Coasts could accommodate these mammoth ships which ranged in size up to 250,000 dwt. The Ports of Los Angeles/Long Beach and terminal points in

Puget Sound in the state of Washington were the only locations with sufficient depth to handle the large vessels. The alternatives available to the respective players then are the same ones currently studied:

1. No action required. Port operations would continue as before. Transshipment points outside the continental United States capable of handling very large ships would be used.
2. Dredge the U.S. ports currently engaged in the trade to a depth which would allow the large vessels to be used with conventional loading methods.
3. Pursue unconventional loading technology which might save large capital investment costs and avoid the lengthy process of obtaining all the approvals necessary to begin a large dredging project. This part of port development is known as the "permitting" process and is addressed in some detail below.

While the technology employed in the loading and transportation of petroleum has application in the movement of coal, the crucial difference in the policy perspectives of the two situations is that the former was in support of a costly though necessary import, while the latter is in support of a valuable export which can have a very favorable effect on U.S. trade balance of payments. The decision made in 1972 was for minimal and passive government participation in the marine loading methods chosen thus allowing the private sector to determine the best alternative. The oil companies chose a combination of continued reliance on transhipment for the East coast, development of offloading terminals at deepwater ports on the West coast and use of an offshore buoy system for the direct off-loading of deep draft tankers at several locations. The first of these buoy

projects has just been completed at the mouth of the Mississippi River and it took an act of Congress, the Deep Water Port Act (1974), to establish the procedures and regulatory structure before such an undertaking could even be started [Ref. 11: IV, p.5]. Other such projects, including one off the coast of Texas, are being considered [Ref. 12: p.19].

The federal government appears to be adopting a more active rcle regarding coal. Stimulation of this trade is not only beneficial for the balance of payments, but stands to benefit the mining and shipping points substantially. A recently completed study for the Virginia Port Authority estimates that ten thousand new jobs, generating two hundred million dollars in payroll are created for every ten million tons of coal exported through the port of Hampton Roads [Ref. 9: p.36]. As in the case of the proposed oil ports of the mid-1970's, it still appears politically naive to justify the expenditure of a large sum for the develcpment of a port based solely on the benefits from a single commodity. A broader approach which considers all the socio-economic aspects of a particular port's development appears better balanced politically, standing a better chance of success.

It must be recognized that the choices relating to which marine loading method to support and where the marine terminal is to be situated are complex political as well as economic decisions. The current flurry of legislative activity in the Congress pertaining to port development is a clear reflection of interest in this area. Leaving the specific details of each method until Chapter III, the following represents a synopsis of the candidate loading alternatives. These should act as background for the ensuing discussion of issues facing the federal government in the general area of port development:

1. Construct artificial islands offshore as transhipment terminals to accommodate super colliers. The coal will be moved to these points by barge or smaller colliers.
2. Transport coal conventionally to the coast for processing into slurry and pump to offshore buoys for loading.
3. Construct a slurry pipeline complex from mineheads in the interior to offshore loading buoys for transoceanic transport by super tanker or specifically configured super colliers.
4. Undertake no federally funded port improvements in U.S. ports, relying on the marketplace to provide the necessary incentive for investment by the private sector.
5. Initiate improvements in the Inland Waterway system to provide a single deepwater export terminal at the mouth of the Mississippi River.
6. Dredge selected U.S. ports to a 55 foot depth to accommodate conventionally designed super colliers of up to 150,000-175,000 dwt displacement.

D. ISSUES FACING THE FEDERAL GOVERNMENT IN PORT DEVELOPMENT

The federal government has, until very recently, played a pivotal role in U.S. port development through the financing and oversight of all channel and turning basin construction. The source of this authority is found in two documents: the U.S. Constitution, Article 1, section 9 which mandated a federal port development policy which would be free from any bias, commercial or otherwise; and the General Survey Act of 1824 which established Congressional funding actions for the creation and maintenance of navigable waterways. Historic interpretation of the first has

inhibited the development of a system of prioritization for port development projects. The second document introduced the U.S. Army Corps of Engineers into the process. Today, many organizations in both the legislative and executive branches of the federal government are part of the Public Works funding and oversight process. All major construction projects and maintenance of the channels in the ports have, until recently, been funded with federal monies. In contrast to this, offshore development in the form of oil platforms and buoy systems has been promoted by the private sector. A tradition has been established in the marketplace to view these dredging projects and maintenance services as free goods. By this it is meant that no specific taxes or use fees have been levied against the principal beneficiaries of these public works, the ports and the shipping industry. No other sector in the transportation industry currently enjoys such a benefit. The highway taxes paid by the trucking industry help support the highways; the sums paid by the airlines in order to use the nation's airports help recoup the cost of the airport itself as well as pay for its operations. It seems, therefore, inequitable that continued investment in dredging should be the financial responsibility of the federal government alone.

Marine construction, particularly channel dredging, has become a very costly undertaking. For example, necessary channel improvements to drop channel depth to 55 feet for the four major U.S. ports, Hampton Roads, Baltimore, Mobile and New Orleans, will cost in the vicinity of 1.5 billion 1980 dollars [Ref. 1: p.19]. This money is not readily available in this era of ever increasing federal deficit budgeting. More restricting than the availability of funds, however, is an entrenched regulatory procedure which requires up to twenty-five years from project proposal to construction.

Port depth restriction to ships designed to meet the Panama Canal's maximum specifications (PANAMAX) will be felt most acutely in the metallurgical coal market. This is due to the larger steel manufacturers' desire to take maximum advantage of the economies of scale offered by large ships (as much as a 50 percent cost advantage is gained when 150,000 dwt ship is used in place of a PANAMAX of 60,000 dwt). Consequently deepwater marine terminals, particularly in Japan, have been built at the off-loading points adjacent to the steel mills [Ref. 13: p.5]. This in no way is meant to imply that the steam coal trade will be unaffected. The consensus of the coal industry is that the U.S. will not be able to meet its full potential in the international coal market unless it can cater to the full spectrum of collier-types projected for the 1990-2000 timeframe. The above should not be construed as a requirement for all the ports engaged in the coal trade to be dredged to 55 feet. To the contrary, as noted in section B above, by 1990 30 percent of the world's bulk fleet will exceed PANAMAX specifications, therefore, 70 percent of the trade will still be carried in vessels 60,000 dwt or less. The implication here is that there is still a role to be played by the ports whose depth does not exceed 40 feet. We must, however, be able to accommodate the larger ships at minimally one port per coast.

No major federally funded port expansion project has begun in the U.S. in the last five years. This tightness in funds coupled with an excessively long process to obtain the necessary environmental and financial permits to dredge and the current administration's philosophy on the Federal government's role in local development has precipitated the introduction of legislation in the Congress which would shift the decision and cost for channel deepening and maintenance away from the federal government to local

authorities [Ref. 14: p.31]. Appendix B contains a synopsis of the bills currently under consideration. There is little hope that any of these proposals will become law in the near future.

The central issues involved in these policy initiatives are first, the proportionate sharing of dredging costs between the public and private sectors and the mechanisms for assessment, cost recovery and capital formation; and second, the streamlining of the currently long complex and expensive process necessary to obtain approval before a dredging process can be started.

1. Cost Sharing

While in the past the ports have rarely shouldered any of the financial burden of channel construction and maintenance, according to the President of the American Association of Port Authorities, Mr. J. Ron Brinson, U.S. ports are willing to share the cost of needed channel improvements with the federal government, if this action will actually contribute to accelerated port development [Ref. 15: p.9]. Cost sharing can be accomplished via two means, either by the levy of a cost recovery user fee on the identified beneficiaries of the improved port facilities or through direct contribution by the port in the form of a lump sum which could be raised through the sale of state or municipal bonds. There is an almost infinite variety of combinations of these two mechanisms. The debate centers around whether a national standard for channel depth (e.g. 45 feet) should be established, what proportion of the construction, operating and maintenance costs will be borne by the federal government, and finally whether a payback scheme or a "pay as you go" arrangement will be mandated.

Port and export coal industry officials appear unanimous in their opinion that a 45 feet channel depth should be set as a nationwide standard for commercial ports processing more than one million tons of cargo per year. Currently 86 percent of these ports have less than 45 feet, while 56 percent have less than 40 feet. The opinion of the fourteen major ports in the U.S., as expressed by the Executive Director of the Port of Long Beach [Ref. 16: p.11], is that the federal government should continue full financing of channels to 45 feet. Projects to deepen these waterways beyond that benchmark should be shared by local interests and the federal government. Naturally enough, the vast majority of the nation's smaller ports support this same position [Ref. 17: p.13]. The industry is again unanimous in stating that 100 percent cost recovery by the federal government will be impossible [Refs. 15; 16; 17]. A review of pending legislation concerning this issue reveals that in large measure this is also recognized by the lawmakers.

The area where disagreement abounds among the ports and among the legislators is the user fee itself. The large ports suggest a locally determined fee while the smaller ports want a national standard fee. Both sides have well grounded arguments in support of their respective position, but a glance at the economies of scale enjoyed by large ports with large volumes of trade tells the real story. These large volume ports view a national standard fee as a direct subsidy to the smaller ports. The large volume port could assess a smaller individual user fee and gain immediate competitive advantage. Large and small ports alike have their spokesmen in Congress, the proposed Moynihan-Abdnor Bill seems to favor the larger ports, while the Hatfield Bill represents the interest of the smaller

ones. As noted in Appendix B there are many positions in between.

Some analysts feel that the debate over the specific issue of cost sharing for dredging obscures a larger issue. From their vantage point, the dredging issue cannot be separated from the overall port development framework [Ref. 1: p.23]. If it cannot be, then the billions of dollars of private sector investment in the ports must be considered. In this more historical context, the federal contribution in the overall cost-sharing picture is picayune by comparison. Reaganomics and the current Administration's philosophy aside, several substantial arguments have been presented against cost sharing. Detailed presentations are contained in Reference 1. The overall result of cost sharing, say the opponents, will be an unequal and disruptive economic advantage going to the larger ports and unavoidable additional cost being attached to each ton of export coal.

In summary, the issue is a thorny one and will not be easily resolved. There does not appear to be a right and wrong, rather it is a philosophical choice as to which size of port to support.

2. Expedited Dredging

> The government's performance has really been non-performance. It has carried out its end of the port development partnership role in a manner marked more by dilatoriness than a responsibility to the nation's interest in a modern and efficient seaport system affording maximum options to shippers and recievers... The federal government has fallen far short in matching the management skills and initiative of U.S. port authorities in assuring the nation of the sound port system it simply must have. That it takes 20-25 years to authorize and build a federal channel project is in itself an absurdly embarassing commentary on the federal government's responsiveness to the nation's needs for port development.
>
> J. Ron Brinson
> Pres. American Assoc.
> of Port Authorities
> [Ref. 15: p.9]

The U.S. Army Corps of Engineers has had responsibility for creating and maintaining deep water and inland waterway facilities since 1824. During this time a lengthy and complicated procedure has evolved in which the Corps performs or supervises all design engineering and cost-benefit analysis on dredging requests received from the localities. Once this work has been completed, the proposals are transmitted to Congressional Public Works Committees for authorization and appropriation action using the Executive Budget as the vehicle. Once the funds have been appropriated, the Corps then becomes responsible for the management of the construction phase and all subsequent operations and maintenance. This entire sequence of events is normally referred to as the permitting process.

Mr. Brinson's estimate on the amount of time it takes to complete a federally funded dredging project is not extreme according to authoritative sources in the literature. It is a long and complicated process involving Congress and several agencies within the executive branch. Appendix C contains the nineteen steps required by the Army Corps of Engineers. Entwined with this is the inexorable path which a public works project must follow through the authorization and appropriations process in Congress. While construction times can vary as a function of either a project's scale or the availability of funds, the permitting process itself can last as long as 18 to 20 years prior to the start of construction. The permitting process is unwieldly, inefficient and seriously jeopardizes expansion of U.S. trade if port development is any measure of this.

Many ways to accelerate the process have been proposed. These would affect not only the study and review procedures, but the legislative process as well.

3. Project Prioritizing

With a heritage as a coal exporting nation and the bright prospects of a greatly expanded demand for coal, the outlook for the U.S. coal export industry should be bright. A major obstacle in realizing this future is the nearly inexorable process of public works approval. Dredging, the backbone of port development, is but one form of publically funded project whose impact as a tool for economic growth is mitigated by time. A critical review of the entire permitting and funding framework, even with the proposed changes, reveals that a simple and basic management tool is lacking in the process. There is no method of systematically prioritizing any of the dredging projects under consideration. The traditional interpretation of Article 1, section 9 of the Constitution has ensured that they are each considered on a case by case basis [Ref. 1: p.26]. One purpose of this study will be to formulate such a methodology based solely on the cost-benefit relationships of the expanded U.S. export coal trade. This technique will be presented in Chapter IV.

III. EVALUATION OF ALTERNATIVE MARINE LOADING METHODS FOR U.S. EXPORT COAL

A. PREFACE

The U.S. government's role in port development has traditionally revolved around the central issue of harbor and channel dredging. If performance of this role is measured by the amount of time between need identification and the finished product, the federal government has not carried out its responsibility adequately [Ref. 15: p.9]. If performance were based on policy coherence and an ability to prioritize projects, the federal government appears to have been singularly unsuccessful in enacting an effective port development planning and management mechanism [Ref. 18: p.94]. The Deepwater Port Act (1974) was a first step in establishing a rudimentary framework for the development of alternatives to the typical 35' deep East and Gulf Coast ports. It was, however, quite commodity-specific since it was in direct response to a perceived need in the early 70's for deepwater terminals in the U.S. to support the supertanker trade in the oil industry [Refs. 18: p.94; 12: Ch. 4].

By contrast, the Japanese and Western European governments have not had the luxury of adopting such a narrow and ineffective view. In those nations a framework apparently exists for port development planning which extends from the local to the national level, with the central government providing the focal point for leadership. They have demonstrated an integrated process in which all interests have an opportunity for representation at the proper level and, most importantly, in the proper perspective [Ref. 18: p.93].

The issue of port development, whether it be in response to oil or to coal, has traditionally pitted the economists against the environmentalists. As Bragaw , et al. point out in The Challenge of Deepwater Ports, this view, while comforting to some from the standpoint of determining who is "us" and who is "them", is far too simplistic. Bragaw's work speaks almost exclusively to the port issue as it related to imported oil in the middle 70's. Much of the analysis and many of the arguments concerning the port development issue then, continue to have direct application in analyzing the policy alternatives available for the expansion of marine loading terminals to accommodate rising demand for U.S. coal exports.

Bragaw points to three areas where deepwater terminal development policy is either open to undue manipulation or is just poorly defined. The first of these, and perhaps the most obvious, is the environmental hazard posed by any major change in the environment. Be it the displacement of millions of cubic yards of mud to dredge a channel, the selection of a large ground area for the storage of coal prior to shipment, or the construction of an offshore terminal, buoy or an island, some impact on the environment is inevitable as the result of a large marine construction project. The difficult task is to assess the magnitude of the impact. Historically, the environmental lobbies have been highly organized and very effective at creating "no-win" policy confrontations with either business or the government over large scale projects by using the media to create an "all or nothing" image on each issue. Moreover, they have been successful at adapting their cause to make it generally synonomous with any other local opposition to a proposed project.

A second area affecting the future of deepwater ports and terminals is the lack of a broad legislative framework with which to define and administer proposed projects [Ref. 18: p.75]. No legal structure currently exists which comprehensively addresses the central issues of terminal siting, liability, or ownership for offshore marine terminal proposals. According to Bragaw, several states have passed stopgap legislation aimed at delaying any construction of this kind. These laws, however, are nearly all products of lobbying efforts by coalitions of local and national level environmentalists and local opposition factions aimed at impeding development. They are not symmetric legislative products, proportionately representing all views. This minimizes their effectiveness in serving the broad interests of the electorate of each state [Ref. 18: p.77].

Several attempts to legislate broad policy guidelines in marine development have been made at the national level. The Coastal Zone Act (1972) encouraged the states to establish a general framework for the management of the coastal zone under their jurisdiction. Unfortunately, this jurisdiction itself is fragmented and not clearly defined. The impact of this legislation has been limited as a consequence. Another Congressional initiative in this general area was the Deep Water Port Act (1974). This piece of legislation was a commodity specific issue, providing the aegis under which an offshore oil terminal could be constructed on the Gulf Coast. The law, however, which has had the single most pervasive and inhibiting effect on port development is the National Environmental Protection Act (1969) whose broad generalities concerning the quality of the environment and extensive impact reporting requirements have formed the basis of an unending series of litigations in the marine development area.

In summary, no comprehensive legislative policy or section of the U.S. Code has been enacted by Congress to bring clarity to the issue. In the absence of such a legal structure, it is hardly surprising that no administrative mechanism or organization exists within the executive branch whose broad authority might lend coherence to marine development issues.

A third inhibition to rapid development of offshore sites can be termed the socio-economic factor [Ref. 18: p.85]. Stated plainly, people don't want their way of life disrupted. The average citizen in a potentially affected area does not fear the environmental impact nearly as much as he simply resists the changes which the siting of such a superport in his area might bring about [Ref. 18: p.74].

In addition to the three factors discussed by Bragaw, a fourth factor has become increasingly important in port development considerations: financing. The torpor of the world economy, which has most recently been described as a recession by the more optimistic of commentators, coupled with an unprecedented increase in the cost of capital in the U.S. has had a depressing effect on the number of investors interested in a development venture. High interest rates, necessitating a high rate of return, have made traditionally good long term investments appear impractical. Investment prospects are dimmed even further by the current strength of the dollar in the world market. This has made U.S. exports increasingly expensive and foreign demand has consequently softened. The net result is that it is becoming increasingly difficult, if not impossible, to make the prices of commodities shipped from new terminals competitive. Renewed attention is being paid to existing facilities.

B. EVALUATIVE FRAMEWORK

The political, social and economic forces described above are at work in policy determination at all levels of government. Appreciating that these forces form a complex pattern against which to match an evaluation, it is nevertheless important to establish a common and straightforward set of measures and outcomes as a first step towards placing a policy choice in proper perspective. The remainder of this chapter will be devoted to establishing a framework which can be used in evaluating the alternatives, describing the policy alternatives individually, and reaching basic conclusions concerning these options. In performing a first level of evaluation concerning coal terminal choices, a conventional cost-benefit method of balancing measures of cost against measures of effectiveness is used. Each alternative is assumed to be able to accommodate vessels with a 55 foot draft.

The measure of cost is budget outlay adjusted to 1982 dollars. Dredging cost adjustments have been made using figures obtained from the Maritime Administration for annual average costs nationwide to dredge one cubic yard. Adjustments to marine construction costs are derived from annual indices compiled by the Engineering News Review for heavy construction costs throughout the U.S. Regional variations from the national average were not used.

Effectiveness for this analysis is measured by the risk of failure and/or damage to the environment associated with each policy choice. Stated simply, it is the degree of uncertainty that a choice, once made, will be successful. The four measures of effectiveness deemed pertinent to this evaluation roughly parallel (with the exception of technology) the forces at work in the policy making environment discussed in section A. above:

1. Technological risk: The probability that the project under consideration can be successfully undertaken from a technical standpoint. It is an assessment based upon a search of available literature concerning the generalized technology involved and interviews with experienced people in the field. This risk will be assigned values of low, medium or high.
2. Economic risk: The degree to which the investment will provide a service and product with a ready demand in the marketplace. This demand is assumed to provide the climate and opportunity for obtaining the rate of return necessary to make the investment feasible. Demand in this context is viewed in two ways: first, that the product is competitively priced and thus occupies a position in the vicinity of the equilibrium point in the supply and demand structure; second, that the resultant product is attractive to the marketplace. For example, if the least cost method is to produce slurry and haul this in tankers, and this alternative is low in technological, environmental and political risks, the fact that there is no demand for such a product in the international marketplace makes this alternative non-viable from an economic standpoint. In assessing risk in this area, the amount of time necessary to bring the project to completion is also considered. Risk is assigned based upon a review of available coal industry literature, comparison with other commercial projections and interviews with personnel representing the coal industry, individual port authorities, port development analysts and employees of the federal government. The risk is assigned values of low (ready demand), medium or high (little or no demand).

3. Environmental risk: The probability that the project construction or the loading process itself will have a permanent adverse impact on the environment. This assessment is based on a review of available literature and interviews with industry and government employees. Unlike the others considered, this particular risk is external to the structure of the alternative itself. While a project may be low in cost, highly profitable and politically feasible, its effect on an unrelated industry or ecological area may be significant and must be considered. This risk is assigned values of low, medium or high.
4. Political risk: The probability that the project will be rejected by either the government or commerce. It is based on a review of the available literature concerning current Congressional activity on this issue, past performance on the issue of deepwater ports for oil imports, the statements of the Reagan Administration concerning the funding of public works in general (marine construction in particular) and personal estimates made by several experts on the issue from the federal government, port authorities and private industry. This risk is assigned values of low, medium or high.

The criterion to be used in this evaluation of the alternatives is not complex. It is simply to determine which investment is associated with the least risk for the project's cost, i.e. risk averse priorization with project cost being considered secondarily. The next stage is to prioritize any set of existing subalternatives to yield maximum capacity for a given cost ceiling.

C. ALTERNATIVE LOADING METHODS

1. Offshore Islands

a. Description

An alternative initially raised during the oil superport debate of the middle 1970's was the construction of offshore artificial sea islands which could act as transhipment points able to handle ships up to 250,000 dwt. An example of such a proposal for oil was advocated by Soros Associates in 1972 [Ref. 18: p.49]. An island of 500 acres would be constructed with 8 deep draft berths and 13 shallow draft or feeder berths. In order to modify this proposal to handle 100 million tons of coal per year, the size of the island would have to be increased for the additional area required for ground storage and loading equipment.

b. Cost

Approximately $1.52 billion for construction costs and an additional $134.7 million in annual operations and maintenance costs are estimated [Ref. 19: p.249]. The construction costs are those proposed by Soros Associates and adjusted to 1982 dollars. The operations and maintenance cost is derived from a composite cost model originally developed by William E. Turcotte, Chairman, Department of Management, U.S. Naval War College, while conducting research on the oil issue at the Maritime Administration during the same period of time in which the Soros' proposal was developed. These amounts are probably lower than the actual costs of a "coal" island, but the difference could not be calculated since neither has ever been built. The projects are similar in scale which is the reason that these estimates are used.

c. Technological risk

The technological risk associated with this project is evaluated as high based on the sheer size of the project and the difficulties experienced in building smaller islands as oil drilling platforms in the Beaufort Sea.

d. Economic risk

This risk area is evaluated as high based on the absence of any current plans for such a system of transhipment in the private sector and a construction time of eight years. Moreover, creation of such a terminal would have an adverse effect on the geographically separated marine terminals in existence or planned for by 1990 and the existing rail transportation system. The activity level of such a large single purpose terminal, dedicated to a single commodity, will be subject to market fluctuations on a far larger scale than its multi-purpose port counterpart. In sum, it is doubtful whether the cost of transhipment coupled with the rate of return needed on such a project would be offset by the reduction in ocean freight rates in a manner which would result in U.S. export coal being competitively priced regardless of throughput. This is illustrated with the following example. The amortization of a $1.52 billion construction cost might range from $203 million per year at 12 percent over a 20 year period to $231 million per year at 15 percent over 30 years. Add to these amounts the $135 million annual operating cost plus a $2.00 per ton transhipment cost (drawn from figures produced by WOCOL). This means that each ton of coal handled in this 100 million ton per year facility, will carry a surcharge of $5.38 to $5.66. When this is contrasted with the $1.25 per ton savings in freight costs when using a 150,000 dwt collier in place of a 50,000 dwt vessel on the same 7000 mile round trip (see

Figure 2.1), it is quickly concluded that the benefit of being able to use the large collier is overshadowed by the additional cost burden to be assumed if this alternative is selected.

e. Environmental risk

This risk is evaluated as high since construction of a large artificial structure such as a sea island would obliterate a portion of the ocean bed at least the size of the island,

> ...not to mention the peripheral destruction around the base of the island structure due to heavy silting and disturbed sedimentation. The back and forth traffic required to transport and deposit the building materials would disrupt normal ecological activity in the water column and on the ocean floor beneath the travelled routes. Finally, given that conventional practices would be used and/or dredging activity in inland and coastal waters would result in massive environmental destruction and degradation. [Ref. 18: p.63]

f. Political risk

Politically, the risk associated with the alternative is evaluated as high based on the geographic singularity of the proposal and the adverse effect its operation would have on the existing commercial infrastructure. As noted earlier in this chapter, the above risk is further compounded by the lack of legal or regulatory mechanisms with which to control such a project.

2. <u>Slurry Pipelines: Shore Site to Offshore Loading Buoys</u>

a. Description

This alternative, as well as the next one, as individual projects do not provide the full capacity needed to satisfy the overall export requirements projected for the

year 2000. They are viewed instead, as complementary to other larger scale efforts to increase capacity. Moreover, they are aimed specifically at satisfying the demands of the super collier trade between now and the early 1990s.

Slurry technology, the process of placing particles of a commodity in a liquid medium and transporting them hydraulically through pipelines, is one that was developed in the last few years of the 19th century. Until now, it has gained no commercial popularity, with only one pipeline system in the nation operating in the Southwest. The principal inhibitors to the expansion of the coal slurry industry in the U.S. have been the existing railway system with its low freight rates and natural reluctance to provide rights of way or eminent domain to slurry supporters and the difficulties in deliquifying the coal once it has reached its destination. Technology has progressed to the point where it is now considered feasible to pump slurried coal through a pipe to a buoy loading terminal in deepwater onto a specially configured collier or reconfigured tanker. This ship performs the dewatering (separation of the coal from the water) and returns this slurry water to the pumping station ashore for recycling. The offshore portion of this system consists of a Single Point Mooring (SPM) buoy supplied by a submarine pipeline. The SPM could be located as far as 18 to 20 miles offshore depending on undersea topography.

A slurry pipeline system such as the one proposed by Wheelabrator-Frye of New Hampshire, which avoids the issues of eminent domain and environmental hazards (described under the next alternative) which have plagued inland pipeline efforts, seems to be a representative and realistic example of what might be accomplished in this area [Ref. 20]. Summarizing this plan, offshore terminals are

being considered for as yet to be selected locations on the East and Gulf coasts: North Carolina and Alabama. Coal would be transported to near shore ground storage by conventional means. The coal would be slurried at that site, then pumped to an SPM and delivered to a 140,000 dwt collier in much the same way as oil is loaded and unloaded at the more than 100 SPM petroleum terminals worldwide. After dewatering aboard ship the coal would be delivered dry to its destination. Initial capacity would be 4 to 5 million tons per year with the potential to expand to 16.5 million tons per year per SPM location.

An alternative, but less attractive proposal would provide for slurry load and slurry unload of the coal from a larger class of ship in the 250,000 dwt category using the same SPM system. The unattractiveness of this proposal lies in the lack of a current or projected market for slurried coal in suspension.

A key feature of the Wheelabrator-Frye proposal as stated in the project description and reiterated by the project manager is that government funding is not sought. The investment is to come entirely from the private sector. The role of the federal government is anticipated to be in the area of regulatory and administrative mechanisms which will speed up the permitting process.

b. Cost

While Wheelabrator-Frye does not seek any federal funding at present, the costs of the project will be included in the alternative evaluation process as a generalized example. The Wheelabrator-Frye project manager for this slurry terminal proposal estimates the cost of this project between $200 and $250 million per location. This figure does not include the price for the special

reconfiguration of the ships designed to load and dewater the slurry, then transport the coal abroad. Four ships per SPM location are estimated by Wheelabrator-Frye as necessary to adequately support each buoy location. The cost for the conversion of all four colliers is estimated to be no more than $35 million. This sum notwithstanding, this project appears to compare favorably with the only large scale offshore petroleum unloading buoy system which is situated off the Louisiana coast. This site opened in May 1981 after seven years of permitting and political negotiation, three years of actual construction, and a cost of $773.5 million [Ref. 21].

Annual operating and maintenance costs for this coal terminal alternative are difficult to calculate since a similar project has never been undertaken. Borrowing once again from the petroleum industry, some gross approximation of these costs can be determined from a study conducted by Raytheon Company in 1974 [Ref. 22: p.83] and Professor Turcotte's previously referred to work. The annualized costs associated with the operation and maintenance of a petroleum SPM are $29 million. Considering the more labor intensive nature of coal transportation and yard operations, $29 million per year can probably be considered as the very least such operations would cost. The cost of slurry water in a recycling pipeline of this length is inconsequential. The cost of rail transportation for the coal is not included.

c. Technological Risk

The risk assessed for this project is medium based on the success of the offshore oil superport in Louisiana, but offset by the unproven feability of the dewatering facilities aboard the specially configured colliers and the loading and water return system in the buoy.

d. Economic Risk

The economic risk is assessed as medium to high. The entire project is dedicated to the movement of a single commodity. Continued slackness in coal demand, either as a result of continued lower crude oil prices or increases in the use of nuclear power in electricity generation will have a more adverse effect on this single purpose port project than it would have on a conventional multi-purpose port. This is offset by the relative speed, four years, needed to put such a marine terminal into operation. As of March 1982, no definite commitments either by the coal industry or by Wheelabrator-Frye existed for the start of this particular terminal option.

e. Environmental Risk

The risk attributed to the undertaking of this project is low. Coal is relatively inert in salt water so that a rupture in the submarine pipe would not, it is estimated, represent a grave and lasting threat to the environment. A question traditionally raised by environmentalists in discussing slurry pipelines for inland use has been the enormous amount of water required to keep the system operating. This particular proposal for a short offshore slurry pipeline avoids such an issue by recycling the water from the collier back to shore analogous to a liquid conveyer belt. This water could, theoretically, be used indefinitely with replacement required only for the water remaining on the coal after dewatering (6-8 percent by weight). To place this in context, a 16.5 million ton per year facility would undergo a net loss of approximately 283 million gallons or roughly 20 percent of the yearly consumption of a small city such as Monterey, Ca. (population less than 30,000 with no heavy industry), according to figures provided by the California American Water Co.

f. Political Risk

The political risk attributed to this alternative is medium. This particular proposal avoids all of the controversy concerning eminent domain encountered by inland slurry pipeline advocates since it uses conventional transportation to the near shore staging point. As noted earlier in the chapter, the uncertainty associated with the lack of a legislative and administrative framework within which to develop and operate this proposed offshore facility detracts from its attractiveness to investors. It is important to recognize that this project will meet near term surges in coal demand because it can be built so quickly. It complements longer term more efficient solutions which provide more capacity for the investment dollar.

3. Coal Slurry Pipeline: Mine Head to Offshore Loading Buoy

a. Description

This alternative is an extension of the previous alternative. Coal would be slurried at the minehead or some central location in the coal fields and then transported in a conventional slurry pipeline to the coast then by submarine pipeline to an offshore SPM for loading and dewatering on board the colliers. An example of such a system is the Pacific Bulk Commodity Transportation System. This proposal was the result of a Maritime Administration sponsored feasibility study to move 10 million tons of coal per year from Emery, Utah to offshore loading buoys located off Port Hueneme on the southern coast of California, a distance of 650 miles [Ref. 23].

b. Cost

The approximate construction cost of this project is $584 million [Ref. 24: p.93]. The annual operating and maintenance cost of a pipeline-buoy loader of this length using water recycling are estimated to be $79 million (for pipeline operations, water and buoy terminal maintenance) [adapted from Ref. 25: p.98 and information provided by the Maritime Administration]. Unlike the previous alternative, these annual costs do include the transportation of the coal. Slurry advocates claim that coal can be transported overland more economically by pipeline than by rail. Lack of empirical data other than that from the single operational slurry pipeline in the U.S. (Black Mesa), however, leaves this claim largely unsubstaniated. It is assumed that four collier conversions will be required to service each location. Being a Maritime Administration sponsored study, these ships would presumably be U.S. flag carriers. Since there are no large colliers currently in the U.S. inventory, the study included an adjusted cost of $331 million for the construction of colliers specifically designed for this task. This contrasts sharply with the previous alternative's cost for ship conversion since the former relies on conversion of existing large colliers in foreign fleets rather than new construction.

c. Technological Risk

The technological risk for this proposal is assessed as medium. The inland portion of the slurry pipeline is low risk as evidenced by the smooth and nearly uninterrupted service of the only operational coal slurry pipeline in the U.S., the 274 mile Black Mesa line in the Southwest. The imponderables remain, as in the last alternative, the unproven nature of the buoy itself and the shipboard dewatering facilities.

d. Economic Risk

The economic risk assessed for this proposal is assessed as high. It has all the risk elements of the last alternative, but with a much higher capital outlay. Ten million tons of capacity are produced for an investment of $584 million which does not compare favorably with Wheelabrator-Frye's proposal of 16.5 million tons for a $250 million investment. Since the inland and offshore portions of this transportation system could be constructed simultaneously, the amount of time necessary to to bring this alternative into operation is not thought to be much greater than the four years estimated for the last alternative, once the issues of eminent domain and permitting are resolved. While several conventional slurry pipeline delivery systems designed to supply domestic utilities are in varying stages of development by private sector enterprises [Ref. 26], there are apparently no commerical backers for this particular one.

e. Environmental Risk

The risk to the environment posed by this proposal is assessed as low based on the rationale given for the previous slurry pipeline and the apparent lack of any substantial environmental hazard regarding the use of large quantities of water from the interior since this system is also designed to recycle the water used [Ref. 26: p.27]. Moreover, the excellent record established over a period of years by the Black Mesa pipeline suggests that the inland portion of this proposal will have little if any impact on the environment.

f. Political Risk

The political risk for this slurry proposal is assessed as high. Two major issues, the availability of water for the pipeline in the arid coal fields of Utah and the risk of pollution by this method of coal transportation, appear to have no real basis in fact [Refs. 23; 24; 26]. They are, however, issues which environmentalists and other local opposition can easily capitalize on and use litigation to delay development efforts.

The true high risks in this proposal involve the issue of eminent domain and the staunch opposition of the railroads. Eminent domain, the right of a public utility or public project to claim land along a right of way is a right which has thus far eluded the slurry lobby at the national level, although favorable legislation has been passed by several Western states. Several bills pertaining to this subject have been defeated in Congress through the late 1970's, and the prospects for early resolution in that arena remain dim [Ref. 24: p.95]. The railroad lobby has effectively opposed the granting of the right of eminent domain to the pipeline interests. The railroad's rationale is tripartite: existing rail and barge transportation capacity is sufficent to meet future needs; the pipelines will have a severely disruptive effect on future railroad operations; and since slurry pipelines need long term contracts with users to make the projects feasible, they restrain free trade and competition. Even the GAO comments [Ref. 23: p.12], that "Most sources agree that... there does not appear to be a transportation shortage problem in terms of coal movement by rail at this time or in the foreseeable future."

While certain selected domestic pipelines, particularly the project promoted by Energy Transport

Systems Inc. (ETSI), stand a good chance of completion, the overall political case for regular use of pipelines to move export coal is not strong in a political or sociological context [Ref. 24: p.95]. The final and perhaps ultimate political issue concerning this alternative is that there is apparently no interest in the private sector for this type of export project. Any investment by the federal government in this type of transportation system would place it in direct competition with the private sector's existing coal transport system and the state or municipal ports that currently do the coal loading. In addition to the obvious disruption which this project would have on a regional coal chain, it appears to be in direct contradiction to the current Administration's political philosophy concerning the role which the federal government should play in the U.S. economy.

4. <u>No Port Improvement Actions</u>

a. Cost

While there is no investment cost associated with this policy choice, the opportunity cost is very high. Industry estimates project an aggregate loss of as much as $8 billion per year in U.S. balance of payments by the year 2000 [adapted from data contained in Ref 2: p.512] This figure is based on a projected leveling off of total coal exports from the U.S. at 125 million tons per year resulting from the nation's inability to offer a full spectrum of competitive prices. This will come as result of U.S. ports being unable to accommodate colliers larger than PANAMAX size due to channel depth limitations. The exceptions to this will in all likelihood be the ports of Long Beach, Ca. and Los Angeles, Ca. since both these ports already have deep water and are planning additional coal handling

capacity. Details of these plans are contained in subsection 6.

b. Technological Risk

None.

c. Economic Risk

The economic risk in choosing this alternative is assessed as high when viewed from the perspective of lost trade and opportunity costs. As noted by Carl Bagge, President of the National Coal Association, the industry's principal trade and lobbying organization, at a September 1981 port conference,

> "With every $15 billion increase in sales of American manufacturing products abroad, the use of domestic goods increases by $22 billion. In turn, this creates about one million jobs, adds $38 billion to the GNP, stimulates $4 billion of new investment, and adds $12 billion in new tax receipts." [Ref. 27]

Annual U.S. foreign exchange earnings from coal are predicted to rise an additional $12.5 to $16.5 billion by the year 2000 based on a current price of $50 per ton [Ref. 2: p.433]. Thus the amount of benefits mentioned by Mr. Bagge will become the opportunity costs or benefits foregone should this alternative be selected.

d. Environmental Risk

None.

e. Political Risk

The political risk is estimated as medium because the high opportunity cost of this alternative has a passive yet adverse impact on the growth of an important segment of the national economy and therefore a direct influence on the political viability of the choice.

5. <u>Inland Waterway Improvements to Supply a Mississippi Superport</u>

a. Description

Marshalling the vast transportation resources of the Mississippi Basin, both rail and barge, this alternative proposes the use of the lower Mississippi River as a coal superport. Like the first alternative, it seeks to meet the projected shortfall in coal export capacity through a single massive project. This proposal would take advantage of the central location of the Mississippi River and its tributaries to export coal from Appalachian, Mid-Western and Western coal fields from a single point. For the purpose of this analysis, capacity at this port is assumed to be 100 million tons per year.

b. Cost

Selection of this alternative would necessitate upgrading and repair of key portions of the inland waterway at a cost of approximately $773.5 million [Ref. 28: p.32]. The cost to dredge the portion of the Mississippi river to accommodate large colliers is estimated to be in the neighborhood of $489 million. [Ref. 29: p.19]. Overall project cost totals $1.262 billion.

c. Technological Risk

The risk assessed is low since it uses conventional and proven technology in all aspects of development.

d. Economic Risk

The risk inherent in this proposal is assessed as high, based on the long leadtime necessary for project completion. Refurbishment of the inland waterway is

estimated to take 20 years, while dredging of the lower Mississippi River could be complete five years after the permitting process is completed. It is felt that this delay would have as severe an inhibiting effect on the U.S. being able to meet increases in the near term demand for steam coal as doing nothing at all.

e. Environmental Risk

Risk in this area is also assessed as low to medium. A full discussion of the possible environmental impact of extensive dredging as would have to be done in the lower Mississippi River is contained in the subsection on selective port dredging presented below.

f. Political Risk

The political risk in choosing this alternative is assessed as high. The economies of scale resulting from the ability to accommodate colliers up to 150,000 dwt and the concentration of coal loading resources in one area, would be offset by the major disruption such a policy would have on a large segment of the existing coal export infrastructure. The rail networks carrying coal to both East and West coasts which are beginning to approach capacity would become vastly underutilized. Congestion on the Mississippi River would greatly increase. Other existing ports, particularly Mobile, would feel a distinct and lasting adverse impact. To place a disproportionate share, roughly one-half, of what may turn out to be the United States' largest commodity export by 2000 in a single region does not appear to be balanced politically. In all likelihood the choice to pursue such an alternative would be opposed from nearly all quarters.

6. <u>Support Dredging in Selected Ports</u>

a. Description

Support of dredging in selected U.S. ports would require the federal government's commitment to two courses of action. The first is to fund a capital outlay, in whole or in part, for the dredging of selected coal ports in the U.S. to accommodate colliers up to 150,000 dwt. The process of selecting which ports is the subject of Chapter IV. The second requirement is to streamline the permitting process so that the dredging projects themselves will be more responsive to the nation's needs. Shortening this process will have the additional benefit of spurring private sector investment in the coal terminals themselves since the present value of the investment will rise as the return on the investment will begin sooner.

b. Costs

The total cost of this program to the federal government is variable depending upon which port is selected (a function of where the best and strongest private sector commitments to the expansion of pierside coal handling facilities reside), the availability of funds, and the portion of the dredging cost which the federal government will bear. Some representative cost figures are as follows:

Hampton Roads: $442 million,
Baltimore: $375 million,
New York City: $165 million,
Philadelphia: $3.5 billion,
Morehead City, N.C.: $18 million,
Mobile: $462 million, and
New Orleans/Baton Rouge: $489 million. [Refs. 28 and 29]

To place these figures into the context of the federal budget currently being debated, Hampton Roads, Baltimore, New York City, Mobile and New Orleans can all be dredged for less than two billion dollars. This sum represents five percent of the annual federal public works expenditures which amount to almost $40 billion [Ref. 30: p.23].

Absent from this list and of significant note when considering the coal industry in the western U.S. are the ports of Los Angeles and Long Beach. Both ports are already able to accommodate tankers up to 100,000 dwt. A fledgling coal export trade in the neighborhood of one million tons per year per port has developed. Both cities have ambitious plans for the expansion of this trade with Long Beach preparing for 15 million tons per year by 1985 and 30 million tons per year by 1990. Los Angeles is planning on expansion to 10 to 15 million tons per year by 1990.

Annual maintenance costs for these expanded channels will increase over their current levels. While these costs will vary depending on the port selected, it is, for example, estimated that if Hampton Roads, Baltimore, Mobile and New Orleans were selected for dredging, annual maintenance costs would increase by $88 million [Ref. 28: p.31].

c. Technological Risk

Port dredging is a proven technology. Risk in this area is assessed as low.

d. Economic Risk

The economic risk of this alternative is assessed as low. Market fluctuations notwithstanding, future demand for coal will almost surely grow significantly. The ability to offer at least one deepwater port on

each coast will increase the coal industry's ability to respond to different demands from users worldwide. The economic advantage of the deepwater port is not limited to coal. Any export commodity which lends itself to bulk shipment will enjoy a similiar advantage. Coal, predicted as the largest export commodity (in terms of balance of payments) by the end of the century can be seen in this context as a catalyst to bring about needed changes. Project completion time is variable based on which ports are selected for dredging and what inroads can be made in expediting the permitting process.

e. Environmental Risk

The risk to the environment posed by the selection of this alternative is assessed as low to medium. Substanial controversy exists over disposal of the sludge and other debris which would result from a large dredging project. Two basic options exist: displace the sludge to deeper water offshore or use it as landfill in land reclamation. The latter course of action if carried out within the environs of the dredged port itself appears to have less potential impact than the dumping of vast quantities of tidelands mud offshore in a deepwater environment.

A second area of risk associated with this alternative is the effect which the dredging process itself may pose to the environment. Most of the ports in the U.S. are industrial centers. Prior to the beginning of public awareness of environmental and pollution concerns in the 1960's, vast quantities of highly toxic industrial waste was dumped into rivers which run to the ports and into the waters of the ports themselves. Much of this material has settled in the harbor bottoms and been covered by subsequent alluvial deposits, thus removing the toxins from direct

contact with local marine life forms. The act of dredging in and of itself may disturb some of these deposits located beneath the proposed channels and release these substances into the waters of the harbors once again.

f. Political Risk

This alternative is assessed as having low risk. It is popular with the private sector. Political controversy over which ports to dredge is inevitable, but because this program is widely distributed geographically and incremental over time, the bargaining process which drives both the legislative and executive branches will be able to operate to minimize much of the disagreement.

D. CONCLUSION

A summary of the evaluation is contained in Table V. Certain qualitative differences exist between the alternatives. First, alternatives two and three in their present form only provide part of the additional capacity required. Second, the cost of alternative two is not a cost to the federal government. Finally, the cost of no action is an opportunity cost not an outlay of funds, and must be viewed in a different light than the other costs.

Applying the criterion selected at the beginning of this chapter, that of minimizing risk with cost being a secondary factor, indicates support for two alternatives: a slurry-pipeline from a near-shore staging point to an offshore loading buoy and selective port dredging for East and Gulf coast ports. Neither program entails unacceptable risk and both complement and support the existing coal industry infrastructure.

Support of an offshore buoy system, such as the one advocated by Wheelabrator-Frye does not require an outlay of

TABLE V

Deepwater Terminal Evaluation Summary

	Add'l Capacity (MT)	Cost ($M)	Technology Risk	Economy Risk	Environment Risk	Political Risk
Sea Island	100	1500	H	H	H	H
Shore-Ship Slurry	16.5	250	M	M-H	L	M
Overland-Ship Slurry	10	584	M	H	L	H
No Action	0	8000	None	H	None	M
Waterway Upgrade	100	1262.5	L	H	L-M	H
Selective Dredging	.75-152.7	9-2725.5	L	L	L-M	L

federal funds. Instead, cost is in the form of support to establish a definitive and expedited permitting process which will assist entrepreneurs in attracting capital to fund the project and bring it into operation at an early date. It is both a near term solution and a complementary measure to more efficient long term initiatives since it will fill a gap in export capacity which is predicted for the mid to late 1980's [Ref. 20: p.13], before expanded port facilities which it will complement become available.

Support of the above alternative is insufficient in the long term. The dredging of selected ports, funded at least partially by the federal government, and developed under a new set of expedited permitting guidelines is also required if any credence is lent to the overwhelming body of evidence

presented by academic, industry, and government studies that the export steam coal trade will increase greatly by the year 2000. The U.S. must be prepared to meet the demand. This program is incremental both in time and the selection of projects, thus it is the single course of funding action which remains viable in an environment of budget ceiling uncertainty. Moreover, being geographically separated, thus giving wider distribution to the benefits accrued, it represents the most politically attractive course of action from the stand point of actually achieving agreement in Congress.

IV. A MODEL FOR PRIORITIZATION OF PORT DEVELOPMENT

The process for the selection of ports for dredging to improve import/export throughput has, historically, been a highly political process. In contrast, the model presented in this chapter depoliticizes the prioritization process for dredging projects. The results of this systematic selection scheme could be used as a framework for the more complex political bargaining process which will yield a final policy decision. Selection is based on the level of federal funding available and the total (national) increase in export capacity. While this model is specific for coal, it can, with little modification be expanded to other bulk commodities and be made to integrate the different commodities' prioritization schemes to aid in determining total port development requirements.

To function correctly, all ports under consideration must be included in the model. A reduced sample has been chosen as an example of the process. Seven coal ports have been selected for consideration: Hampton Roads, Baltimore, New York City, Philadelphia, Morehead City, Mobile and New Orleans/Baton Rouge. The overall cost of coal shipped from Gulf coast ports is competitive with the cost at East coast ports. Mobile and New Orleans, for example, are closer to the Japanese markets than, say, Hampton Roads. Conversely, coal can be delivered by barge to these ports more cheaply than corresponding rail transport required further north. This lower cost on the inland link of the coal transport chain compensates for the slightly higher ocean freight rates from the southern ports to the European markets than those enjoyed by their East coast counterparts. The

necessary input data such as capacities (existing and potential) and costs were determined or computed and a selection of dredging projects for various budget ceilings was made. While the data used is current, no specific conclusions can be drawn from the port projects selected in this case since a small sample was used and not all the ports competing were considered for this example.

The actual choice of which ports to dredge should not be made on the basis of finances alone. A prioritization based on efficiency, as this one is, acts as an excellent foundation upon which to overlay the socio-economic and political factors that must also be considered before the final decision is made.

This model considers a port's current coal export capacity, proposed projects which will expand the capacity of that port, the likelihood that those projects will be completed, and the share (percent) of the dredging cost which the port is willing to assume.

A. PRIORITIZATION

The criterion in determining which ports should be dredged is the gaining of maximum benefit (capacity) for a given budget ceiling without elaborating for socio-economic or political factors.

1. Expected Total Capacity

The current annual coal handling capacity and proposed improvements/additions which would increase capacity for each port were ascertained from a literature search and from interviews with port authorities. Columns (1) and (2) of Table VI summarize these data. Certain ports, particularly the larger ones, have more than one expansion project planned for their coal handling

TABLE VI

COAL EXPORT CAPACITIES BY PORT

Port	(1) Current Capacity	(2) Add'l Capacity of Proposed Projects	(3) Completion Rating of Project	(4) Expected Total Capacity	(5) Expected Capacity W/O Dredging	(6) Growth Potential Index
Hampton Roads	65	30 15 12 5	H H H H	127.	96.	.1403
Baltimore	16	12 10 15	H H S	41.75	28.88	.0687
New York City	1	10 10 10	S S S	8.5	4.75	.0455
Philadelphia	3	10	H	13.	8.	.0029
Morehead City	3	15	VS	4.5	3.75	.0833
Mobile	9	11	H	20.	14.5	.0238
New Orleans	27.5	15 80	H S	62.5	45.0	.0716

Capacities in million metric tons per year.

Ratings: H = Hard
M = Medium
S = Soft
VS= Very Soft

facilities. Each of these projects has a different sponsor and is located in a different part of the port. Considering the vaguaries of commerce and the rapid waxing and waning of enthusiasm in the marketplace, it is unlikely that all of these additional projects will be completed, so a method to estimate the most likely future level of port capacity is necessary. Each of these proposed expansions was rated as either hard, medium, soft or very soft based on its likelihood of completion. Reasons for non-completion might be economic, environmental or regulatory. The assignments were based on information obtained from the American Association of Port Authorities and a spokesman for the Maritime Administration. They represent professional estimates as to the actual commitment of the proposal's sponsor and the expected economic viability of the project. They are, of necessity, fluid assessments which are obviously subject to shifts in the market demand for export coal and the cost of capital to a particular developer. An expected value for new total physical capacity for each port was calculated by assigning probability values to the completion ratings and summing the products of each project's increase in capacity with the probabilty value of that particular project and the current capacity (Equation 4-1).

$$C_t = C_c + \sum_{i=1}^{n} P_i \; C_i \,, \qquad (4\text{-}1)$$

where: C_t = Expected Total Capacity of the port,

C_c = Current capacity of the port,

P_i = Probability value assigned as the likelihood that project i will be completed,

C_i = Additional capacity gained in completing project i, and

i = Individual project number.

The probability values used were:

Hard = 1.00

Medium = .50

Soft = .25

Very Soft = .10

2. Effect of Dredging on Capacity Utilized

Provided contracts can be signed (i.e. U.S. coal is competitive with other suppliers), it is assumed that close to 100 percent of this new physical capacity will be utilized. Conversely, if U.S. coal is not competitive, for instance as a result of failure to reduce freight rates as a consequence of neglected dredging, it is reasonable to expect that only a fraction of this increased coal loading capacity will be used in a particular port. In this example, the penalty or loss as a result of not dredging was set at 50 percent of the additional capacity planned. The variable DREGEFF in Appendix D reflects this impact on utilization. Column (5) of Table VI shows the expected capacity if no dredging operations are undertaken.

3. Selection of A Dredging Program

The optimal choice of which ports to dredge, based on the maximum total capacities of each of the candidates, is determined for specific budget ceilings ranging from $200 million to the amount of federal funds necessary to fund all of the projects. A listing of these costs is presented on page 60. The federal share is calculated by subtracting the portion of the costs that the non-federal agencies are willing to underwrite from the total cost. For this example, 50 percent local cost sharing is assumed for all ports. A review of pending legislation determined that this 50/50 split is an often proposed option, though by keeping

the actual proporation negotiable, competition to raise local shares by the ports wanting federal funds for dredging could be encouraged. All of the possible combinations of dredging projects were enumerated, computing the total federal cost and total capacity achieved. Those combinations which result in total costs greater than the given budget ceiling were eliminated. The last step, selection of the two programs with the largest total expected capacities, provides two alternative dredging programs which will provide the greatest total coal export capacity for a particular budget ceiling. Table VII shows the optimal and next best programs for varying budget amounts. Figure 4.1 plots the federal cost versus the total capacity of the optimal programs for increasing budget ceilings. Of significance is the discrete nature of the stepped increases in capacities which are a function of the size and cost of the individual projects. In this sample, the principle of diminishing marginal returns is clearly illustrated, with each increment of spending purchasing fewer tons per dollar. The return is particularly poor past one billion dollars.

4. Growth Potential Index

If, due to fiscal, time or other resource constraints, only one of the dredging projects within a particular program can be undertaken at one time, a secondary level of prioritization to select the project which should first receive funding could be found using the Growth Potential Index (GPI). The GPI is the ratio of the expanded capacity as a result of dredging to the size of the federal investment. The larger the ratio, the better the potential for growth. It is calculated by subtracting column(5) from column(4) of Table VI and then dividing the remainder by the federal share of the cost of the dredging

TABLE VII

Optimal and Next Best Programs for Various Budget Ceilings

(1) Budget Ceiling ($M)	(2) Total Cost ($M)	(3) Capacity Achieved (M Ton)	Hampton Roads	Baltimore	New York City	Philadelphia	Morehead City	Mobile	New Orleans/Baton rouge
200	196.5	214.50	0	1	0	0	1	0	0
	187.5	213.75	0	1	0	0	0	0	0
400	312.5	236.38	1	0	1	0	1	0	0
	303.5	235.63	1	0	1	0	0	0	0
600	557	253.88	1	0	1	0	1	0	1
	548	253.13	1	0	1	0	0	0	1
800	744.5	266.75	1	1	1	0	1	0	1
	735.5	266.00	1	1	1	0	0	0	1
1000	975.5	272.25	1	1	1	0	1	1	1
	966.5	271.50	1	1	1	0	0	1	1
1200*									
2400	975.5	272.25	1	1	1	0	1	1	1
	966.5	271.50	1	1	1	0	0	1	1
2600	975.5	272.25	1	1	1	0	1	1	1
	2494.5	271.75	1	1	1	1	1	0	1
2725.5	2725.5	277.25	1	1	1	1	1	1	1
	2716.5	276.50	1	1	1	1	0	1	1

1 = Complete dredging project
0 = Do not dredge

* No change in optimal or next best solution between $1000M and $2400M.

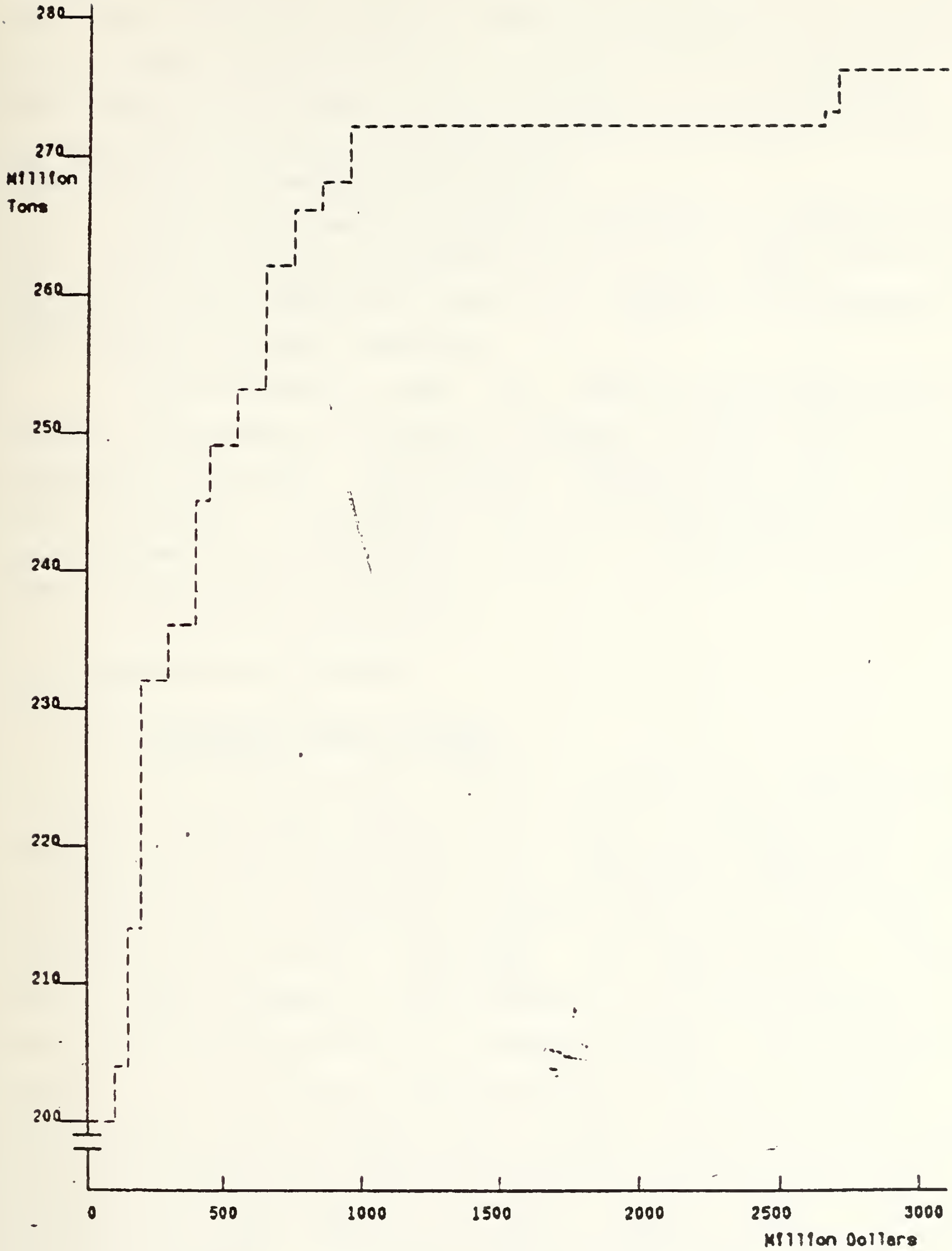


Figure 4.1 Federal Cost vs. Total Capacity

project. Each port's GPI is listed in column (6) of Table VI. This ranking by GPI is effective as long as a predetermined number of projects has been specified, otherwise the GPI prioritization may not be optimal. In this case, an enumeration of all the possible combinations must be used to determine the necessary priorities.

From the example results contained in Tables VI and VII, Hampton Roads and Morehead City, N.C. stand out as the locations where greatest growth in capacity is achieved for the dredging dollar invested.

Of additional note, the use of this prioritization scheme encourages the ports to assume a larger share of the dredging cost since the smaller federal cost for a particular capacity, the greater the likelihood that a project will appear in the selected program. It also increases the GPI for that particular port.

B. SENSITIVITY ANALYSIS

1. Dredging Effect Factor

As stated above, if U.S. coal is not competitively priced in the world market, it is safe to assume that in all likelihood the additional coal handling capability made available in a planned expansion will not be used to capacity in a port not dredged. In other words, dredging has a direct effect on the portion of the new capacity of a port which will be used on a routine basis. In the example above, a 50 percent dredging effect factor was used. To test whether the educated but inexact choice of this factor does not adversely effect the optimal program selection, the model was rerun using 10 percent and 90 percent dredging effect factors. The ten best programs at each budget ceiling were compared one against the other and again with

those computed using the original 50 percent factor. While the total national capacity varied as a result of differing levels of utilization, in each case the priority list of possible programs remained the same.

The choice of the dredging effect factor while modifying the capacity utilized had no effect on the selection of the optimal dredging program for the example analyzed.

2. Cost Sharing Factor

The percentage of the cost that each local authority is willing to assume is a factor in the model. In the example, 50 percent was used for each port. Provided all ports' percentage are identical this common factor has no effect on the program prioritization. The federal cost for each program is proportional to the example model.

The final outcome of legislation designed to establish the minimum local percentages is not discernible at this time, although 50 percent seems likely. Regardless of the final established rate, local authorities may opt to fund a larger share than they are legally required to bear. This increase would reduce the federal cost for the same capacity increase. It may cause that port's dredging project to be included in the optimal dredging program and will increase the GPI for that port. The larger GPI impacts favorably on funding considerations.

For example, if Mobile's share of the dredging costs could be increased from the previously used 50 percent to 90 percent, while keeping other ports' at 50 percent, then Mobile's dredging project would appear in the optimal and the next best programs at all budget ceilings considered from the $400 million level to the maximum ceiling. In the original example, Mobile's project did not appear until the $1 billion budget ceiling. This increased cost share also

increased Mobile's GPI from .0238 to .1190, a shift upward in the GPI prioritization from sixth to second.

Additionally, if each port assumed a greater share of the cost so that their GPI approximated that of Hampton Roads in the example (0.1403), then the total cost to the federal government to fund all the projects in this sample would be $546.5 M instead of $2725.5 M. A breakdown of federal costs per port under this assumption is found in Table VIII. This manipulation of the GPI illustrates the level of investment needed by each locale in order to make it competitive with the base case, Hampton Roads.

TABLE VIII

Federal Costs With Approximately Equal GPI's

Port	Percentage of Cost Assumed by Local Authorities	GPI	Federal Cost ($M)
Hampton Roads	50 %	.1403	221
Baltimore	76	.1431	90
New York City	84	.1420	26.4
Philadelphia	99	.1429	35
Morehead City	70	.1389	5.4
Mobile	91	.1323	41.58
New Orleans/Baton Rouge	74	.1376	127.14
			546.5

The percentage of cost sharing has no effect on the selection of the optimal dredging program if all ports assume identical percentages of cost sharing. Only when differing percentages among the ports are used will the optimal program selection be affected.

3. <u>Probability of Project Completion Factor</u>

The probability weights assigned to the completion ratings of Hard, Medium, Soft and Very Soft were changed from 1.00, .50, .25 and .10 to 1.00, .75, .50 and .25

respectively. While this did not change the optimal and next best programs selected at any budget level, the ranking of lower priority programs did in fact shift. The model was also run with .90, .75, .60 and .30 as the probability values. Once again, the top two programs remained the same while the lower priority programs shifted ranking with the exception of the $400 million budget ceiling where each of the top eight programs shifted in priority. This shift of the lower priority programs at different budget ceiling levels stresses the need for caution in assigning values to these weights. For this particular study, the writers assigned the numerical weights to this project completion factor assessment. In future, the assessor himself would be asked to create the numerical scale for the ranking. While this factor would remain a subjective judgment in an overall sense, a clearer picture of the differing magnitudes of degree of commitment between "hard" and "soft" would be available.

Table IX shows the optimal and next best programs for the various budget ceilings using the first alternative weights. As before, Hampton Roads clearly dominates all the candidates both in terms of its expansion's scope and the apparent industry commitment behind it.

TABLE IX

Optimal and Next Best Programs for Various Budget Ceilings Using Alternative Weights

(1) Budget Ceiling ($M)	(2) Total Cost ($M)	(3) Capacity Achieved (M Ton)	Hampton Roads	Baltimore	New York City	Philadelphia	Morehead City	Mobile	New Orleans/Baton rouge
200	196.5	234.25	0	1	0	0	1	0	0
	187.5	232.38	0	1	0	0	0	0	0
400	312.5	258.00	1	0	1	0	1	0	0
	303.5	256.13	1	0	1	0	0	0	0
600	557.0	285.50	1	0	1	0	1	0	1
	548.0	283.63	1	0	1	0	0	0	1
800	744.5	300.25	1	1	1	0	1	0	1
	735.5	298.38	1	1	1	0	0	0	1
1000	975.5	305.75	1	1	1	0	1	1	1
	966.5	303.88	1	1	1	0	0	1	1
1200*									
2400	975.5	305.75	1	1	1	0	1	1	1
	966.5	303.88	1	1	1	0	0	1	1
2600	975.5	305.75	1	1	1	0	1	1	1
	2494.5	305.25	1	1	1	1	1	0	1
2725.5	2725.5	310.75	1	1	1	1	1	1	1
	2716.5	308.88	1	1	1	1	0	1	1

1 = Complete dredging project
0 = Do not dredge

* No change in optimal or next best solution between $1000M and $2400M.

V. CONCLUSIONS AND RECOMMENDATIONS

A. CONCLUSIONS

Overwhelming evidence exists in both the public and private sectors that the export of coal from the U.S. will continue to grow in size and importance as the century draws to a close. Market fluctuations in oil and coal notwithstanding, the world's supply of fossil fuel is finite and, over the long term, increases in value, since no truly adequate alternative is at hand. Almost inevitably much of the world must turn to coal as a more abundant and less costly fuel than oil. The U.S., as the largest producer and potential supplier of coal must be adequately prepared to meet increasing demand in order to reap the full benefits of a more favorable balance of payments and stronger ties with other western nations based upon the United States as a competitive and secure source of energy.

This study grew out of earlier work which focused on the need for deepening East and Gulf coast ports. In expanding the research to include the Pacific ports, it was anticipated that the prioritization scheme for dredging would become a large and complex matrix with a large number of West coast ports in the competition. This did not happen. First of all, the coal industry in the western region of the U.S. was found to be very different from its eastern counterpart. The latter demonstrates a tight, integrated connection all the way from the coal fields to the loading piers at the ports. In the West, the coal industry is still new and each link in the coal chain is separate and distinct from every other. The overall impression is one of more fragility than its more robust eastern cousin.

More important than the above, though, is the conclusion that not every port that wants to be part of the coal trade needs channel depths to 55 feet. The entire trade is not going to super colliers. Based on demand projections, port expansion plans, and the portion of the coal trade anticipated to be carried in very large ships, Los Angeles and Long Beach appear to complement one another in their development plans and will accommodate deep draft demand for the Pacific Rim trade. The balance of this trade will go to smaller coal ports restricted to servicing PANAMAX size vessels. A sizeable portion of the steam coal trade will remain in this class of ship since many of the destination ports in the Pacific area are not planning to dredge beyond their current 35 to 40 feet. The result of the above is that the question of dredging to 55 feet becomes geographically specific to the East and Gulf coasts. Therefore given steam coal demand projections through the end of the century and a budget ceiling, the optimal selection of ports to be dredged can be made using the model presented in Chapter IV.

Effective satisfaction of this increased overall demand will be based on a rationalization of the U.S. export coal trade to permit this nation to accommodate the entire spectrum of demand. A key ingredient is the ability to handle ships larger than the PANAMAX size at at least one large coal loading terminal on each coast. With the exceptions of Los Angeles and Long Beach in California, the remainder of the U.S. port system will not be able to effectively adapt to the growing usage of large ships in the bulk trade.

The current state of port and offshore terminal development is haphazard, tedious and politically biased. A truly comprehensive plan for port development and a system to administer it is not in evidence, nor is it anticipated in the near term. A framework of planning and control, founded

on a solid base of legislation, is required now to avoid increasingly inefficient port development and the inevitable cost to the taxpayer both in actual costs and revenues foregone.

The federal permitting and funding procedures pertaining to port and offshore development are in need of streamlining if any solutions, either interim or long term, to the projected gap between world demand and the loading capability of the U.S. are to be found. A 25 year cycle is too long.

If the model in Chapter IV is considered valid, then its use indicates that the more financial participation a locale is willing to make in a project, the more attractive the development of that particular port will appear in the prioritization process. This is, in fact, in consonance with the principles of "new federalism" espoused by the Reagan Administration.

Rationalizing the need for deepwater terminal development based upon the economics or lobbying power of a single commodity, be it coal, oil or grain, will prolong the fragmented and parochial views which currently prevail. A coalition of several interests is needed to ensure that the selection of ports to be dredged truly serves the national economy. Without a top down, systemic approach which articulates goals and methods designed to reach a broad and balanced economic objective regarding port and offshore terminal development, much of the benefit predicted for the U.S. as a result of increased foreign trade in the last years of this century may be lost. In this context, coal must be a catalyst rather than a cause of change.

B. RECOMMENDATIONS

The prioritization scheme presented in Chapter IV which treats more than one port at a time and which is ultimately based on the increased coal export capacity which will accrue to a particular port if selected for dredging should be used as an analytical tool in a rational port development process. While outside the scope of this study, it is assumed that this general methodology would be applicable to the study of commodities other than coal in determining a priority for the development of other commodity specific terminals. This should be tested.

More complicated, but of greater value in bringing coherence to the analysis of port development, further research should be conducted to determine which measures of effectiveness should be used in performing a generalized, non-commodity related prioritization for the development of U.S. ports. While difficult to ascertain, these measures will provide homogeneity to this multi-faceted process.

Specific legislation and administrative mechanisms in support of offshore buoy loading system development to meet a near term gap in export capability are required now. The permitting and funding process for channel dredging in selected ports must be placed on a "fast track" basis. While the coal trade will be one of the most immediate beneficiaries of this action since it would then be able to more adequately accommodate the ballooning of demand forecasted for the mid-1990's, the entire U.S. bulk trade, import and export alike, will become more economical and gain a competitive advantage when larger ships can be used.

In 1976 Marcus, et al., after studying federal port policy, concluded that, while much needed to be done to systematize development in this area through centralization, there was little hope that the diverse bureaucratic factions

playing roles in port or offshore development could be brought together into a single bureaucratic entity [Ref. 12: p.219]. Increased cooperation among the many players making port policy was the only viable recommendation offered at that time. Much has changed politically and economically since then. While tangential to the issues analyzed in this study, it is concluded that the time has come to bring order, reason and moderation to the port and offshore development process by scrapping the traditional interpretation of that portion of the Constitution purported to deal with bias and prioritization in port development (but which really appears to be a 200 year old compromise arrived at during the transition of the Articles of Confederation to the Constitution) and bring this effort into the twentieth century through the centralization of the planning, regulation and programming functions under the leadership of an independent agency. This organization should have much the same power and general organizational characteristics as the Federal Communications Commission, the Interstate Commerce Commission, and the Small Business Administration. The nation can no longer afford the existing ineffective and costly coalition of managements in this vital area. It is recommended that further research in the form of cost-benefit and political feasibility studies be undertaken to determine exactly what actions are necessary to implement this centralization and escape from the currently chaotic and ineffective process.

APPENDIX A

PROJECTED DISTRIBUTION OF STEAM COAL SHIPMENTS IN TON-MILES BY SHIP SIZE - (PERCENT)

Ship Size (thousand dwt)

	-20	20-35	35-50	50-80	Sub Total	80-100	100-150	150+	Total
1980	10	13	22	43	88	5	7	-	100
1985	6	7	19	39	71	4	17	8	100
1990	4	6	13	27	50	6	27	17	100
1995	3	5	10	24	42	6	30	22	100
2000	2	4	8	21	35	7	33	25	100

Source: "Interim Report of the Interagency Coal Export Task Force," Draft for Public Comment, U.S. Department of Energy, January 1981, using as reported from original source of H.P. Drewry Shipping Consultants Ltd., September 1980, Arthur D. Little Inc.

APPENDIX B

SYNOPSIS OF MAJOR PORT DEVELOPMENT LEGISLATION

A. HOUSE BILLS

1. HR 2959/5073

a. Description

- Introduced April 1, 1981 as Administration's proposal to recover dredging costs for port improvements.
- Authorizes collection of user fees on traffic through ports.

b. Status

- Howard and Clavsen introduce administration's revised proposals as HR 5073.

2. HR 4627 Port Development and Navigation Improvement Act of 1981

a. Description

- Introduced Sept. 30, 1981 by Biaggi (D-NY), co-sponsored by Jones (D-NC), Boggs (D-LA), Bevill (D-AL), Breaux (D-LA), Pritchard (R-WA), Tauzin (D-LA), Foglietta (I-PA), Miketlaha (D-MD), and Livingston (R-LA).
- Reduces to two and one half years the time for Congressional authorization, funding and construction.
- Federal funding of capital and O&M of channel depth to 45 feet.

- New construction greater than 45 feet:
  - 50-50% sharing of constuction costs;
  - 75% local payment of O&M.
- Calls for timely maintenance dredging.
- Port by port user fees for construction and maintenance in those few ports that need and can share costs.

b. Status

- Referred to Committees on Merchant Marine and Fisheries, Public Works and Transportation, and to Rules.
- Unanimously approved by Committee on Merchant Marine and Fisheries.
- Synder (R-KY) ammendment requiring 4 percent of dry bulk imports/exports be carried on U.S. flag ships unanimously passed.

3. <u>HR4691 Port and Waterways Maintenance, Development and Improvement Act of 1981</u>

a. Description

- Introduced Oct. 5, 1981 by Wyden (R-OR).
- 50-50% sharing for O&M of shallow and deep draft waterway improvements.
- 50-50% sharing for new construction greater than 13.5 meters (44.3 feet).
- Uniform national tonnage fee on all international commerce (commodity specific).
- Fees deposited in Inland Waterways Trust Fund (PL 95-502) used for federal share of O&M and new construction.

b. Status

- Referred to committees on Public Works and Transportation and to Merchant Marine and Fisheries.

4. HR 4810

a. Description

- Introduced Oct. 21, 1981 by Smith (D-PA).
- Prohibits user fees for dredging or maintenance of any channels in U.S. navigational waters.

b. Status

- Referred to Public Works and Transporation Committee.

5. HR 4862 National Defense Port System Act of 1981

a. Description

- Introduced Oct. 29, 1981 by Matsui (D-CA) and co-sponsored by Fazio (D-CA), Chappie (R-CA), Derwinski (R-IL), Garza (D-TX), Mitchele (D-MD), Murphy (D-PA), Bonker (D-WA), Ginn (D-GA), Gerngrich (R-GA), Lantos (D-CA), Gibbons (D-FL), Hatcher (D-GA), Wilson (D-TX), Napier (R-SC), Harlnett (R-SC), and Lehman (D-FL).
- Treasury to collect uniform national fees on ships drawing less than or equal to 45 feet.
- These fees go into a Port System Trust Fund which is used by the federal government for new projects to 45 feet and for O&M of channels and harbors to 45 feet.

- For new construction greater than 45 feet, the port can borrow monies from the trust fund and repay government from port specfic fees charged on ships or cargoes greater than 45 feet.

b. Status

- Referred to Merchant Marine and Fisheries Committee.

6. HR 5276 Multimodal Transportation Act

a. Description

- Introduced December 16, 1981 by Atkinson (R-PA), Bowen (D-MS), Applegate (D-OH) and Luken (D-OH).
- "Provides for fair treatment of all modes of transportation on a fair and euitable basis..."
- Would return 60 percent of the net annual customs receipts to the transportation modes, rail, highway, waterways, and airways, in proportion to the contribution of each mode to the import trade.

b. Status

- Jointly referred to the House Energy and Commerce, Public Works and Transportation, and Ways and Means Committees.

B. SENATE BILLS

1. S 809

a. Description

- Introduced April 1, 1981 as Administration's proposal to recover dredging costs for port improvements by Stafford (R-VT).
- Authorizes user fees on traffic through ports.

b. Status

- Opposed by Democratic National Commitee.

2. S 1586 Waterways Transporation Development and Improvement Act of 1981

a. Description

- Introduced Aug. 3, 1981 by Hatfield (R-OR) and co-sponored by Thurmond (R-SC).
- Allows for commodity specific tonnage charge.

b. Status

- Referred to Committee on Environment and Public Works.
- Considered dead, has been superseded by S 2217.

3. S 1692 National Harbors Improvement and Maintenance Act of 1981

a. Description

- Introduced Oct. 1, 1981 by Abdnor (R-SD) and Moynihan (D-NY).
- Ports to pay 25% of maintenance of deep draft channels and harbors at depth and width

currently authorized by law (Deep draft is considered to be 14 feet).

- 50-50% sharing of maintenance of channels and harbors deepened by local authorities.
- Ports to repay 100 percent of the cost of all new channel and harbor projects.
- Authorizes collection of user fees only to extent that they reflect the service and benefit of channel/harbor improvement. (User fees are not mandatory.)
- Authorizes $250 million annually for port maintenance.
- Establishes a procedure to consolidate into a two year period the processing of all permits that may be required prior to construction of any harbor improvement.
- Allow completion of projects started provided reimbursement of work undertaken after 9/30/82 is made within 50 years.
- No new construction allowed after 10/1/82 unless in accordance with bill or in interest of national defense.

b. Status

- Referred to Environment and Public Works Committee.
- Water Resources Sub-Committee approved.
- Reported out of Environment and Public Works Committee with several minor amendments.
- Packwood (R-OR) asks for Finance Committee consideration. He is circulating a letter to gather signatures in support of this referral ("Packwood Letter").

- Reported to the floor in Dec '81 but not considered due to hold requested by Thurmond (R-SC) and Hatfield (R-OR).
- Democratic National Committee stated opposition.
- Administration has indicated its support of this bill.

4. S 2217 National Defense Port System Act of 1982

   a. Description

   - Introduced March 16, 1982 by Hatfield (R-OR), Thurmond (R-SC), Mattingly (R-GA), Nickles (R-OK) and Nunn (D-GA). Hawkins (R-FL) added as co-sponsor.
   - Establishes national uniform duties on cargoes.
   - Calls for the expediting approval and permitting process for deep draft improvements and related landside facilities.
   - Creation of Task Force by Treasury Secretary to develop a schedule of fees and charges on all imports and domestic cargoes carried on vessels with drafts greater than 14 feet.
   - Fees will be collected by the IRS (could designate collection to the Custom Service) and deposited in a Trust Fund.
   - Gives the consent of Congress to local ports to tax exports. If no local tax is levied, then the federal government would be allowed to impose a vessel charge.
   - In order for a port to take advantage of the Trust fund, it would have to impose an export tax.

- The Trust Fund would finance:
  - 100% of O&M costs of ports less than 45 feet,
  - 90% of all new construction less than 45 feet,
  - not available for new construction or maintenance greater than 45 feet, for these the local port authority is required to pay and reimburse the federal government 100% of project construction costs directly allocated and attributable to commercial navigation including interest.
- Allows a state port authority to construct and maintain any improvements without Congressional authority if no federal funds are required.
- Retires the St. Lawerence Seaway debt and includes the Great Lakes as Trust Fund recipiants at the same rates.

b. Status

- Referred to the Senate Finance Committee.

5. S 2402

a. Description

- Introduced April 20, 1982 by Cochran (R-MS) and Stennis (D-MS).
- Similiar legislation to HR 5276.

b. Status

- Referred to Senate Finance Committee.

APPENDIX C

HOW CORPS PROJECTS ARE CONCEIVED, AUTHORIZED, FUNDED, AND IMPLEMENTED

1. Public requests assistance from congressional delegation to solve water resources problems.
2. Committee on Public Works of House or Senate authorizes study.
3. Initial funds for study enacted into law.
4. Corps district conducts reconnaissance (Stage 1 Planning) -- includes public meeting and other forms of public involvement.
5. If results of reconnaissance favorable, Corps district continues study and develops preliminary alternatives (Stage 2 Planning) -- includes public meeting and other public involvement.
6. Corps district selects several alternatives to develop in detail and on the basis of further evaluation tentatively selects plan, which best achieves the objectives of the study (Stage 3 Planning) -- includes public meeting and the preparation and circulation of draft report and draft environmental impact statement (EIS).
7. District engineer submits report and EIS to division engineer.
8. Division engineer submits report and results of division review to Board of Engineers for Rivers and Harbors (BERH) -- includes public notice.
9. BERH reviews district and division recommendations and issues its findings and recommendations -- includes public notice of recommendations.

10. Chief of Engineers coordinates proposed report and EIS with Governors of affected States and Federal department heads.
11. Chief of Engineers report reviewed by Secretary of the Army and the Office of Management and Budget and submitted to Congress -- final EIS filed with EPA.
12. Committees on Public Works hold hearings and include project in authorization bill or authorize by joint resolutions.
13. Initial funds for Advance Engineering and Design (AE&D) for project enacted into law -- usually several years after authorization.
14. Corps reaffirms plan based on current conditions and any new planning criteria applicable to project -- includes a public meeting and other forms of public involvement.
15. If plan reaffirmed, or satisfactorily modified to accommodate new conditions or criteria, Corps continues with sufficent engineering and design to award initial construction contracts.
16. Non-Federal interests required to enter into formal agreement with Secretary of Army to fulfill their obligations, as authorized by Congress.
17. Intial funds for construction of project enacted into law -- requires specific decision by President and Congress to initiate construction of project.
18. Continuation of engineering and design and project construction -- may include adjustments based on results of detailed engineering design.
19. Completion of project construction.

Source: U.S. Army Corps of Engineers (from OTA study)

APPENDIX D

FORTRAN PROGRAM TO COMPUTE COST AND COAL CAPACITIES

```
$JOB
C********VARIABLE DEFINITIONS*********
C
C      DRGEFF = EFFECT ON ADDITIONAL CAPACITY UTILIZATION
C               IF DREDGING IS NOT ACCOMPLISHED
C-----------------------------------------------------------------
C             APPRAISAL OF COMMITMENT TO CONSTRUCT
C                         COAL FACILITY
C      HARD , MED, SOFT, VSOFT : ESTIMATE OF LIKELIHOOD THAT
C                                FACILITY WILL BE BUILT
C-----------------------------------------------------------------
C    THE FOLLOWING ABBREVIATIONS REPLACE "???" IN THE
C    OTHER VARIABLE NAMES:
C      HAM = HAMPTON RAODS
C      BAL = BALTIMORE
C      NYC = NEW YORK CITY
C      PHL = PHILADELPHIA
C      MHC = MOREHEAD CITY
C      MOB = MOBILE
C      NWO = NEW ORLEANS / BATON ROUGE
C-----------------------------------------------------------------
C      CUR??? = CURRENT COAL CAPACITY OF A PARTICULAR PORT IN
C               MILLION TONS (MT)
C      ???PJ1 = ADDITIONAL PHYSICAL CAPACITY OF THAT PORT
C               IF COAL PROJECT # IS COMPLETED.(MT)
C      ETN??? = EXPECTED ADDITIONAL CAPACITY (MT) OF THE PORT
C               PROJECTS COMPUTED IN RELATION TO LIKELIHOOD
C               OF COMPLETION.
C      TON??? = COMPUTED UTILIZATION OF ADDITIONAL COAL
C               CAPACITY (MT) FROM PROJECTS IN THE PORT
C               WITHOUT DREDGING.
C      CST??? = TOTAL COST OF DREDGING THE PORT IN $M
C      PER??? = PER CENT OF DREDGING COST THE PORT IS
C               WILLING TO PAY (%)
C      GPI??? = GROWTH POTENTIAL INDEX (GPI) OF THE PORT.
C
C      COST = TOTAL COST TO DREDGE SELECTED PORTS UNDER
C             CONSIDERATION.
C      TONAGE = TOTAL COAL CAPACITY OF ALL PORTS UNDER
C               CONSIDERATION.
C
C********* VARIABLE DECLARATIONS *******
      REAL COST, TONAGE
      INTEGER I,J,K,L,M,N,O,A,B,C,D,E,F,G
C
C********* INITIALIZE VARIABLES ********
      DRGEFF = .50
C
      HARD = 1.0
      MED = .50
      SOFT = .25
      VSOFT = .10
C
      CURHAM = 65.0
      CURBAL = 16.0
      CURNYC =  1.0
      CURPHL =  3.0
```

```
      CURMHC =  3.0
      CURMOB =  9.0
      CURNWO = 27.5
C
      HAMPJ1 = 30.0
      HAMPJ2 = 15.0
      HAMPJ3 = 12.0
      HAMPJ4 =  5.0
C
      BALPJ1 = 12.0
      BALPJ2 = 10.0
      BALPJ3 = 15.0
C
      NYCPJ1 = 10.0
      NYCPJ2 = 10.0
      NYCPJ3 = 10.0
C
      PHLPJ1 = 10.0
C
      MHCPJ1 = 15.0
C
      MOBPJ1 = 11.0
C
      NWOPJ1 = 15.0
      NWOPJ2 = 80.0
C
      CSTHAM = 442.0
      CSTBAL = 375.0
      CSTNYC = 165.0
      CSTPHL = 3500.0
      CSTMHC = 18.0
      CSTMOB = 462.0
      CSTNWO = 489.0
C
      PERHAM = .50
      PERBAL = .50
      PERNYC = .50
      PERPHL = .50
      PERMHC = .50
      PERMOB = .50
      PERNWO = .50
C
C**************************************************
C   COMPUTE EXPECTED ADDITIONAL PHYSICAL CAPACITY OF EACH
C   PORT BASED ON ESTIMATES OF LIKELIHOOD THAT PROJECTS
C   UNDER CONSIDERATION WILL BE COMPLETED.
C
      ETNHAM = HAMPJ1 * HARD + HAMPJ2 * HARD + HAMPJ3 * HARD
     +         + HAMPJ4 * HARD
      ETNBAL = BALPJ1 * HARD + BALPJ2 * HARD + BALPJ3 * SOFT
      ETNNYC = NYCPJ1 * SOFT + NYCPJ2 * SOFT + NYCPJ3 * SOFT
      ETNPHL = PHLPJ1 * HARD
      ETNMHC = MHCPJ1 * VSOFT
      ETNMOB = MOBPJ1 * HARD
      ETNNWO = NWOPJ1 * HARD + NWOPJ2 * SOFT
C
C**************************************************
C   COMPUTE AMOUNT OF ADDITIONAL CAPACITY UTILIZED IF
C   DREDGING IS NOT COMPLETED.
C
      TONHAM = DRGEFF * ETNHAM
      TONBAL = DRGEFF * ETNBAL
      TONNYC = DRGEFF * ETNNYC
      TONPHL = DRGEFF * ETNPHL
      TONMHC = DRGEFF * ETNMHC
      TONMOB = DRGEFF * ETNMOB
      TONNWO = DRGEFF * ETNNWO
C
```

```
C*********************************************************
C    COMPUTE TOTAL UTILIZATION (CURRENT + ADDITIONAL) IF NO
C    DREDGING IS COMPLETED.
C
      TOTCAP = CURHAM + CURBAL + CURNYC + CURPHL + CURMHC
     +         CURMOB + CURNWO + TONHAM + TONBAL + TONNYC
     +         TONPHL + TONMHC + TONMOB + TONNWO
C
C*********************************************************
C    ENUMERATE ALL POSSIBLE COMBINATIONS OF DREDGING PORTS,
C    COMPUTE TOTAL FEDERAL COST TO DREDGE PORTS AND COMPUTE
C    TOTAL CAPACITY UTILIZED IN EACH COMBINATION.
C
      DO 70 A=1,2,1
         DO 60 B=1,2,1
            DO 50 C=1,2,1
               DO 40 D=1,2,1
                  DO 30 E=1,2,1
                     DO 20 F=1,2,1
                        DO 10 G=1,2,1
                           I=A-1
                           J=B-1
                           K=C-1
                           L=D-1
                           M=E-1
                           N=F-1
                           O=G-1
      COST = CSTHAM*I*(1-PERHAM)+CSTBAL*J*(1-PERBAL)
     +       +CSTNYC*K*(1-PERNYC)+CSTPHL*L*(1-PERPHL)
     +       +CSTMHC*M*(1-PERMHC)+CSTMOB*N*(1-PERMOB)
     +       +CSTNWO*O*(1-PERNWO)
      TONAGE = TOTCAP + I*(1-DRGEFF)*ETNHAM
     +         J*(1-DRGEFF)*ETNBAL + K*(1-DRGEFF)*ETNNYC
     +         L*(1-DRGEFF)*ETNPHL + M*(1-DRGEFF)*ETNMHC
     +         N*(1-DRGEFF)*ETNMOB + O*(1-DRGEFF)*ETNNWO
      WRITE (6,999) COST,TONAGE,I,J,K,L,M,N,O
10                      CONTINUE
20                   CONTINUE
30                CONTINUE
40             CONTINUE
50          CONTINUE
60       CONTINUE
70    CONTINUE
C
C*********************************************************
C     COMPUTE GPI FOR EACH PORT
C
      GPIHAM = (ETNHAM*(1-DRGEFF)) / (CSTHAM*(1-PERHAM))
      GPIBAL = (ETNBAL*(1-DRGEFF)) / (CSTBAL*(1-PERBAL))
      GPINYC = (ETNNYC*(1-DRGEFF)) / (CSTNYC*(1-PERNYC))
      GPIPHL = (ETNPHL*(1-DRGEFF)) / (CSTPHL*(1-PERPHL))
      GPIMHC = (ETNMHC*(1-DRGEFF)) / (CSTMHC*(1-PERMHC))
      GPIMOB = (ETNMOB*(1-DRGEFF)) / (CSTMOB*(1-PERMOB))
      GPINWO = (ETNNWO*(1-DRGEFF)) / (CSTNWO*(1-PERNWO))
C
C*********************************************************
C     PRINT GPI FOR EACH PORT
C
      WRITE (6,991) GPIHAM
      WRITE (6,992) GPIBAL
      WRITE (6,993) GPINYC
      WRITE (6,994) GPIPHL
      WRITE (6,995) GPIMHC
      WRITE (6,996) GPIMOB
      WRITE (6,997) GPINWO
C
      STOP
C
```

```
999     FORMAT (1X,'$',F8.1,5X,F6.2,' MT',5X,7I2)
991     FORMAT (1X,'GPI OF HAMPTON ROADS = ',F6.4)
992     FORMAT (1X,'GPI OF BALTIMORE = ',F6.4)
993     FORMAT (1X,'GPI OF NEW YORK CITY = ',F6.4)
994     FORMAT (1X,'GPI OF PHILADELPHIA = ',F6.4)
995     FORMAT (1X,'GPI OF MOREHEAD CITY = ',F6.4)
996     FORMAT (1X,'GPI OF MOBILE = ',F6.4)
997     FORMAT (1X,'GPI OF NEW ORLEANS/BATON ROUGE = ',F6.4)
        END
$ENTRY
```

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